TECHNICAL BULLETIN No. 138 OCTOBER, 1929

E&A
IN 2 BUR.
21 NOV. 1929
ENTOM.

STUDIES ON THE FALL ARMY WORM IN THE GULF COAST DISTRICT OF TEXAS

BY

R. A. VICKERY
Assistant Entomologist, Division of Cereal and Forage Insects
Bureau of Entomology

UNITED STATES DEPARTMENT OF AGRICULTURE, WASHINGTON, D. C.

For sale by the Superintendent of Documents, Washington, D. C. - - - - - - - - - Price 10 cents

STUDIES ON THE FALL ARMY WORM[1] IN THE GULF COAST DISTRICT OF TEXAS

By R. A. VICKERY

Assistant Entomologist, Division of Cereal and Forage Insects, Bureau of Entomology

CONTENTS

	Page
Introduction	1
Nature of injury to corn	2
Food plants	3
Life history and habits	3
Migration of the moth	4
Oviposition	4
Number of eggs in a mass	4
Average number of eggs laid by a moth	5
Feeding habits of the larvae	5
Cannibalistic habits of the larvae	5
Pupation	6
Seasonal history	6
General discussion	6
Occurrence during the winter	7
Duration of the egg stage	8
Duration of the larval stage	11
Duration of the pupal stage	12
Number of generations during the year	14
Parasites of *Laphygma frugiperda*	15
The parasitism as observed at Brownsville	15
Parasites in Texas, Oklahoma, Kansas, Louisiana, and Arkansas	19
Outline of parasitism	20
Chelonus texanus Cresson	21
Apanteles marginiventris (Cresson)	25
Parasites of *Laphygma frugiperda*—Contd.	
Meteorus laphygmae Viereck	28
Rogas laphygmae Viereck	33
Zele melleus (Cresson)	36
Sagaritis dubitatus (Cresson)	36
Neopristomerus appalachianus Viereck	39
Ophion bilineatus Say	39
Euplectrus platyhypenae Howard	42
Frontina archippivora Scudder	45
Archytas piliventris Van der Wulp	45
Beauveria globulifera (Speg.)	49
Spilochalcis pallens (Cresson)	50
Spilochalcis torvina (Cresson)	52
Dibrachys meteori Gahan	53
Eupeiminus meteori Gahan	55
Tetrastichus euplectri Gahan	55
Tetrastichus dolosus Gahan	55
Myrmicomorpha perniciosa Viereck	55
Hemiteles	55
Comparison of the bionomics of the parasites	56
Importance of parasites in protecting corn from the attacks of *Laphygma frugiperda*	60
Cause of outbreaks of the fall army worm	60
Summary	62

INTRODUCTION

Laphygma frugiperda (S. and A.) is, in the adult stage, a moth of the family Noctuidae. It is found in the Tropics of North, South, and Central America, including some of the West Indian Islands, and is undoubtedly tropical in origin; but it appears to be a continuous resident of the Gulf coast district of the United States, where it is able to survive the mild winters. Many of the moths migrate or disperse from the immediate locality where they emerge from the pupae, and these migrations sometimes carry them far beyond the territory where the climate will permit the species to survive. From the district along the Gulf coast where this insect passes the winter, moths migrate northward during the spring, summer, and fall, successive generations passing farther and farther north until they sometimes reach the most northern States of the country. The progeny of these migrating moths do not, however, survive the winter, and the species is destroyed each winter throughout its range in

[1] *Laphygma frugiperda* (S. and A.).

the United States except in a territory of unknown limits along the Gulf coast and in eastern Florida.

The damage done by *Laphygma frugiperda* in its larval stage, known as the fall army worm, to corn and forage crops in the South entitles it to consideration as an important pest of these crops. Outbreaks of the fall army worm are difficult to study, as the entomologist usually arrives on the scene when the caterpillars are full-grown and ready to pupate. To obtain some of the information which might aid in understanding this insect and finally lead to practical results in its control, studies on it were undertaken at Brownsville, Tex. As the insect is continuously resident there, the locality is favorable for this work.

Laphygma frugiperda attacks young corn throughout the Southern States, but usually does not migrate very far north until most of the corn is beyond the tasseling stage. It may be found in August, in the more northern of the Southern States, in ears of corn or on young corn plants grown as a soiling crop. It also attacks other plants in the South, such as sorghum (both the saccharine and nonsaccharine varieties), alfalfa, and tame and wild grasses, but prefers corn if young plants of this crop are available when the moths are flying. It appears every year in the Northern States, late in the season, and attacks the ears of corn, but in these States is seldom numerous enough on corn to attract attention.

In this bulletin *Laphygma frugiperda* is treated as the common pest of corn of the Gulf States known as the "bud worm," and not as the fall army worm. In these States the injury done to corn by this insect is much more extensive than is commonly supposed, as the damage is often mistaken for and reported as the work of the corn-ear worm, or bollworm. The conditions reported in the following pages under the headings food plants, habits, seasonal history, and parasites, are common and usual for this insect throughout the Gulf section of the Lower Austral life zone.

NATURE OF INJURY TO CORN

The moths oviposit on young corn plants from 1 to 2 feet tall, in preference to all other plants. The caterpillars usually are found feeding on the corn leaves, especially those on the young plants before the tassels appear. The large caterpillars commonly remain in the "throat" of the plant, and feed during the day as well as at night. Owing to this method of feeding, the insect is commonly known in the South as the "bud worm." Holes are eaten through the folded leaf which, after it grows out, appear as a row of three or four small-to-large holes across the leaf. If the caterpillars are numerous the leaves are badly frayed. This injury is similar to the injury done to young corn by the larvae of the corn-ear worm *Heliothis obsoleta* (Fab.). By examining the injured plant it is possible, however, to determine which species is responsible for the damage, as the holes cut in the corn leaves by the larvae of Laphygma have nearly smooth edges, whereas the holes cut by the larvae of Heliothis have ragged edges. The caterpillars also feed on older corn plants, entering the ears and feeding on the grain, and causing damage similar to that done by the corn-ear worm. Sometimes the larvae are numerous enough to destroy the corn plants, which may be entirely stripped of their leaves. Even the stalks of young plants

may be eaten to the ground. The young corn plants usually survive and outgrow the ordinary injury to the leaves.

FOOD PLANTS

Laphygma frugiperda has been observed to feed on a large variety of plants, especially during an outbreak of the caterpillars, when they migrate from destroyed grasses and feed on available neighboring plants. Chittenden[2] has listed many species upon which the larvae are known to have fed. Those which have been observed by the writer are here mentioned.

Corn.—This is the cultivated crop that seems to be preferred, and caterpillars may be found on it if young corn is available when the moths are flying.

Sorgo.—This crop is commonly sown broadcast for hay in southern Texas, and the caterpillars frequently attack it. Caterpillars were observed by C. L. Scott in young, broadcast sorgo at Hunnewell, Kans., early in August.

Kafir.—The writer observed caterpillars feeding on kafir at Odem, Tex., in October. In the early part of August C. L. Scott observed caterpillars on young plants 1 to 3 feet high at Colbert, Tishomingo, Yukon, Blackwell, and Enid, Okla., and at Wellington, Kans.

Other sorghums.—In Texas, caterpillars have been observed feeding on feterita, milo, Johnson grass, Sudan grass, and broomcorn.

Alfalfa.—Caterpillars have frequently been swept from alfalfa in the vicinity of Brownsville. In September, at Shreveport, La., the writer observed one small field of alfalfa which had been destroyed by these caterpillars.

Oats.—Caterpillars have been found on this crop in the vicinity of Brownsville in January, February, and May.

Barley.—Caterpillars have been collected from barley at Brownsville in January, February, March, and April.

Bermuda grass.—The caterpillars probably feed frequently on this grass, but are noticed only when numerous. During May and June, 1912, they were common on Bermuda grass at Brownsville.

Croton capitatus Michx.—This plant is common in the pasture land near Riviera and Kingsville, Tex. On November 20, 1918, the writer found caterpillars of Laphygma feeding on *Capitatus* near Riviera, and most of the plants of this species and grasses also in that locality were defoliated. The caterpillars were scarce at that time, but M. M. High stated that they had been very numerous in the pastures about a week before.

Other food plants.—The caterpillars were also observed at Brownsville feeding on sugar cane, peanuts, beans, and a species of Amaranthus.

LIFE HISTORY AND HABITS

The life history and habits of *Laphygma frugiperda* have been described by Doctor Chittenden in his publication entitled "The Fall Army Worm and Variegated Cutworm."[3] He treats of all the stages and includes technical descriptions, by H. G. Dyar, of the larval instars and of the egg.

[2] CHITTENDEN, F. H. THE FALL ARMY WORM AND VARIEGATED CUTWORM. U. S. Dept. Agr., Div. Ent. Bul. (n. s.) 29, 64 p., illus. 1901.
[3] CHITTENDEN, F. H. Op. cit.

At Brownsville the writer determined the sex of many pupae, isolated them into lots, male and female, and reared the moths. In all of the experiments the male moths were of the ornamental or Prodenialike form, while the females were of the dull, gray-colored variety. The larvae taken at Brownsville were usually of the uniform brown color and were not striped.

The following habits, observed at Brownsville, appear to be important: The moths migrate. They deposit eggs on or near green plants that, at that time, are suitable for the larvae to feed upon. They deposit eggs in masses and cover the mass with down from the body of the parent. The larvae feed on the leaves of the food plant; they are gregarious after hatching, but begin to disperse at the end of the first instar. The larvae pupate near the surface of the ground.

MIGRATION OF THE MOTH

No direct proof of the migrations of the moth was obtained in the work here discussed on *Laphygma frugiperda*, but it is generally admitted that this insect does not overwinter in the North, and outbreaks of its caterpillars can be explained only by assuming migrations from the South. It appears to be able to overwinter only in the Gulf district of the Lower Austral zone, but the extent of the area in which it can overwinter is not known, and probably varies from year to year. Part of the early spring infestation along the Gulf coast and in southern Florida may be caused by moths which migrate northward from the Tropics. The northward migration occurs with the advancement of the season, and the moths reach the more northern States after going through successive generations farther and farther north. This migration seems to occur every year, but it reaches the proportions of what are called outbreaks of the fall army worm only in occasional years.

OVIPOSITION

The moths fly at night and hide during the day on the food plant of the larvae. On corn they frequently rest during the day among the unopened leaves of the young plants. In the writer's experiments the female oviposited at night, but it is not certain that they do not oviposit to some extent during the day. They lay their eggs in masses, usually on the upper surface of the leaf of corn, but occasionally on other parts of the plant. The female covers the egg mass with a gray down from her body. The writer observed the egg masses on leaves of the date palm, where the larvae could drop to the ground and feed on Bermuda grass, and the moths are ikely to deposit the eggs on weeds and other comparatively tall planlts in the field, as well as upon the food plants.

NUMBER OF EGGS IN A MASS

The eggs in the masses were counted at various times. One egg mass taken from corn had 100 eggs in two layers, and another taken from corn had 400 eggs in four layers. In an experiment conducted in the laboratory by O. W. Rosewall 43 egg masses were taken from

the breeding cages, and the number of eggs in a mass varied from 9 to 349, with an average per egg mass of 143.

AVERAGE NUMBER OF EGGS LAID BY A MOTH

In the experiments conducted by Mr. Rosewall six pairs of newly reared moths were confined in separate lantern globes and fed on thin sugar sirup. The females began laying eggs three days after they emerged from the pupae, and their average length of life was about six days. The six females laid a total of 6,144 eggs, or an average of 1,024 eggs per female. The total number of egg masses was 43, or about 7 for each female. One moth laid 1,782 eggs in 13 masses.

FEEDING HABITS OF THE LARVAE

When the larvae hatch they eat the eggshells, and for a short time feed in a colony near the egg mass, gradually dispersing as they grow. Toward the end of the first instar they wander farther from the egg mass, and in the second instar they are isolated and usually seek protection between the young leaves of the plant. While in the first and second instars they feed on one side of the leaf, skeletonizing it, but during the later instars they eat holes through the leaf. The caterpillars feed both in the daytime and at night. They usually feed in the shade or in protected situations, such as between the young leaves of corn or in the "throat" of young corn plants. In older corn plants they enter the ear through the silk and feed on the grain near the tip of the ear. They do not have the habit of hiding under trash on the ground during the daytime, as do the cutworms and army worms. As the older larvae, those in the fourth to the sixth instars, may migrate to near-by plants, those hatching from a single egg mass will infest many of the surrounding plants. And if they are numerous enough to destroy the host plants the need of food may compel them to assume the army-worm habit and migrate in large numbers.

CANNIBALISTIC HABITS OF THE LARVAE

These caterpillars will attack, kill, and feed upon each other, so that it is necessary to isolate them in rearing experiments. Several experiments were conducted at Brownsville to learn something of their habits in this respect. Egg masses were placed in 4-ounce, seamless tin boxes, as many as 400 eggs being in each box. All of the caterpillars were confined in a single box until pupation but had a supply of corn leaves for food. Some of the larvae died from unknown causes, but most of them were destroyed by their fellows until only one or two remained to pupate. In one experiment a single corn plant was grown in each of six large field cages 3 by 3 by 6 feet, and from 150 to 200 eggs were placed in each cage. By the time the caterpillars were ready to pupate most of the corn plants had been destroyed, and only from 3 to 18 caterpillars could be found in each cage. No evidence was found to show that the missing caterpillars had been eaten. Some of them may have escaped from the cages in some way, as they were observed to wander around within the cages, apparently seeking other food plants.

No direct evidence of cannibalism was observed in the field and probably it is not an important factor in causing a reduction in the number of caterpillars. Up to and including the third instar many caterpillars can hide between the young corn leaves without interfering with each other, and in the fourth instar there is room for a smaller number, whereas in the fifth and six instars larvae like to occupy the throat of the plant, and there is room for only one in this position. Usually only one large caterpillar can be found in the throat of a corn plant, and undoubtedly the surviving caterpillar has eaten any others that have tried to occupy the confined area of this location, desirable from the standpoint of the caterpillar.

The pugnacious habits of the caterpillars seem to make migration necessary and cause them to seek other plants; if, therefore, an egg mass is deposited on one plant the surrounding plants will ultimately be infested by the migrating caterpillars.

PUPATION

At Brownsville the writer did not collect pupae from the field and made no accurate observations on the method of pupation. Chittenden,[4] in the publication already mentioned, says that they pupate from one-fourth inch to 1¼ inches below the surface of the ground. This slight depth for entering pupation is important, as it limits the northern range of the insect. Deeper pupation would obtain for it a more uniform temperature and allow it to survive a longer period in the ground during the cold months.

SEASONAL HISTORY

GENERAL DISCUSSION

Laphygma frugiperda may be found at Brownsville in all stages during every month in the year, but it is not easily found in December, January, and February because suitable green food plants are scarce during these months. In the collections made for the rearing of parasites (Tables 7 and 8) caterpillars in all instars from the third to the sixth were taken during every month in the year except February. The most numerous collections were made in April, May, June, and July, and in the fall in September, October, and November, because cornfields in the right stages of growth to be heavily infested with the caterpillars could be located during those months, more especially during May, June, and October. Although no pupae were collected from the field in any month, the presence of caterpillars in all stages would indicate the continuous presence of pupae. During August it is more difficult to find the caterpillars on corn, because most of the corn is mature at that time, whereas in December, January, and February there is very little growing corn except a few scattered fields of late-planted fall corn that may survive until January, if there are no freezes.

The cornfields of the lower Rio Grande Valley furnish favorable conditions for *Laphygma frugiperda*. A few fields of corn may be planted in January in the vicinity of Brownsville, but the planting of the main crop begins about the middle of February. After the

[4] CHITTENDEN, F. H. Op. cit.

middle of February some corn is planted every month until October. The early planted corn begins to mature about May, most of the crop being sold for roasting ears in May and June. The cured grain may be harvested in June, July, and August. Sometimes in August or September corn may be planted for a fall crop of silage, or to furnish roasting ears in November. The Mexican farmers plant corn in the resaca bottoms after the fall rains, or at any time after an overflow of the river. By the middle of March corn may be found in all stages of growth up to a height of about 2 feet, and from that date until the beginning of December cornfields infested with Laphygma may be found at any time.

Alfalfa may also furnish food for the caterpillars during the spring, summer, and fall months. For the purpose of rearing parasites, the writer made collections from alfalfa in June, July, August, September, and October.

Sorgho planted broadcast for hay is also available during the months in which corn is available, and Bermuda grass and other wild grasses may be found in most of the months of the year, especially along the irrigation canals.

OCCURRENCE DURING THE WINTER

During the winter months, December, January, and February, it is more difficult to find caterpillars of *Laphygma frugiperda* in the field, for the number of growing food plants is diminished by the cold weather. This species can not go through the winter in the pupal stage because in the winter at Brownsville this stage lasts only between 30 and 40 days, and as the ground is not frozen the moths emerge. Part of the winter must, therefore, be passed in the larval stage, and the scarcity of green food plants reduces the numbers that survive the winter. In some winters there are severe freezes, the temperature going below 32° F. and killing practically all of the food plants of this insect. Large numbers of the caterpillars must be destroyed as a result of these freezes, as they would starve to death after the destruction of their food plants. Such freezes last only a few days and rarely occur; the winters are usually mild, with many warm days and only a few light frosts. In mild winters a few fields of corn may last until January, as also may sorgho in hayfields. Some green Bermuda grass and other wild grasses may also be found unless very dry weather occurs. In January, February, and March the caterpillars may sometimes be found on oats, but this crop is not sown to any considerable extent in the lower Rio Grande Valley.

Some observations taken from the writer's field notes are presented in the following paragraphs to give an idea of the winter conditions under which this insect occurs at Brownsville.

On December 20, 1913, moths were found on corn plants, and caterpillars in all stages were found in the same field. On the same day one egg mass was collected from corn about 3 feet tall, growing in the laboratory plot. On December 23, in another field which had plants about 3 feet high, about 50 per cent of the plants were infested, and there were caterpillars in the fourth, fifth, and sixth instars. In the collections made for the purpose of rearing parasites (Tables 7 and 8) 781 caterpillars were taken in December in seven collections

in the course of the years 1913, 1914, and 1915. These collections were made on December 2, 16, 20, 24, 28, and 30.

On January 15, 1913, many fifth-instar and sixth-instar caterpillars were collected from corn which had survived the frosts. On January 31 of the same year one caterpillar was taken from barley.

On January 7, 1914, a search was made by two men for Laphygma caterpillars in a field of corn which contained two plantings, one part of the field having plants in the roasting-ear stage and the other plants from 1 to 3½ feet tall. The latter planting had been severely injured by frost. Only five caterpillars were taken in two hours' careful search. On January 15, one Laphygma moth, one egg mass, one fourth-instar caterpillar, and one sixth-instar caterpillar were taken from corn in the laboratory plot in 5 minutes' time. This corn was about 3 feet tall and had twice been injured by frost.

On January 6, 1915, caterpillars in the third, fourth, and fifth instars were collected from the laboratory corn plot. On January 14 about 200 caterpillars ranging in development from the third to the sixth instar were collected from a cornfield on a sugar-cane plantation. The corn had been planted late in the fall for silage, but wet, cold weather had retarded growth, and the plants were only from 1 to 2 feet high on January 14.

In the collections made for rearing parasites 457 caterpillars were taken in January in six collections, in the course of the years 1913, 1914, 1915, and 1916. These collections were made on January 5, 6, 7, 13, 14, and 27.

On February 18, 1911, a few small caterpillars were collected from corn about 6 inches high which had been planted on January 1. On February 10, 1915, a few caterpillars were collected from oats. No caterpillars for parasite rearings were collected in February.

DURATION OF THE EGG STAGE

Numerous experiments, some in every month of the year, were conducted to ascertain the length of the incubation period. In all cases the egg masses under observation were inclosed in tin boxes.

Experiments were conducted in the laboratory by O. W. Rosewall from June 13 to August 11, 1913, with the result that the incubation period was found, on the basis of 17 observations, to vary in length from approximately two days to three days. It was more than 48 hours and less than 72 hours, at an average daily mean temperature of 79° F. It was less than 48 hours at an average daily mean temperature of 80°.

Experiments were conducted in the insectary by C. L. Scott in 1913 and 1914, and in the laboratory by Felix V. Garcia in 1915 and 1916, numerous observations being made by both during the months from September to May, inclusive. These experiments are summarized in Table 1. The mean temperatures ranged from 59° to 79° F. The laboratory temperatures were very uniform, with a daily range of from 4° to 6°; but the insectary temperatures had a daily range of from 15° to 25°. At mean temperatures of from 77° to 79° the duration of the egg stage was less than 3 days, and at 59° it was more than 10 days. At mean temperatures of from 62° to 69° the duration of the egg stage in the laboratory was shorter than

in the insectary at the same mean temperatures. At mean temperatures of between 70° and 76° the duration of the egg stage appeared to be slightly longer in the laboratory than in the insectary.

TABLE 1.—*Duration of egg stage of Laphygma frugiperda as related to daily mean temperatures observed at Brownsville, Tex., in the years 1913 to 1916, inclusive*

Mean temperature of incubation	Number of observations	Range of duration of egg stage	Average duration of egg stage	Mean temperature of incubation	Number of observations	Range of duration of egg stage	Average duration of egg stage
° F.		Days	Days	° F.		Days	Days
59 to 61	12	10¼–12	11	70 to 74	12	3¼–5	4
62 to 65	10	8 –10	8½		[1] 27	3 –5½	4¼
	[1] 10	5 – 8	7	75 to 76	10	3 –4	3¼
66 to 69	18	5 – 7	6		[1] 8	3 –4½	3½
	[1] 20	4 – 7	5½	77	8	2½–3	([2])
				77 to 79	[1] 11	2½–3½	([2])

[1] These observations were made in the laboratory; the others in the insectary. [2] Less than 3.

The length of the egg stage at the temperatures usually maintained in a refrigerator was roughly determined by placing five lots of eggs in an ordinary household refrigerator as soon as practicable after they were laid and leaving them there until at least part of them hatched. Three such lots were exposed in December, 1915, one being placed in the refrigerator 3½, and another 2½, days after being laid, and a third with practically no time intervening. In February, 1916, two such lots were placed in the refrigerator, one 3½ days and the other immediately after being laid. The history and results of these experiments are summarized in Table 2. The two lots of eggs transferred to the refrigerator immediately after being laid hatched in 18 and 19 days, respectively, after being kept at mean temperatures of approximately 52° and 53° F. The lot of eggs transferred to the refrigerator 2½ days after being laid hatched 12 days after the transfer, the intervening mean temperature being 52°. The two lots so transferred after 3½ days hatched in 4 to 8 days, respectively, at mean temperatures of 52° and 53°. In the later of these two cases the eggs of one mass hatched February 20, 1916, and a few eggs in other masses hatched on the next day. No more of these eggs hatched in the refrigerator, but several masses which were removed from the refrigerator on the 20th hatched in the laboratory the next day.

In all of the experiments recorded in Table 2 the eggs were inclosed in tin boxes, each box containing a piece of wet blotting paper to keep the air moist; in one experiment, not summarized in the table, the egg masses were kept dry in a vial, and although the embryonic development was completed the eggs failed to hatch. The development of the embryos proceeded slowly at these temperatures, and the embryos became fully developed larvae ready to emerge on the day the eggs are recorded as hatching, but in most cases only a few of the larvae actually emerged. Egg masses which failed to hatch in the refrigerator when embryonic development was complete also failed to hatch when removed several days afterwards from the refrigerator, which shows that the larvae die within the egg if low temperatures have prevented them from emerging.

TABLE 2.—*Duration of egg stage of Laphygma frugiperda, entirely or mainly at refrigerator temperature, observed at Brownsville, Tex., in 1915 and 1916*

Date eggs were laid	Date eggs were put in refrigerator	Date eggs hatched	In laboratory before being put in refrigerator		In refrigerator	
			Time	Mean temperature	Time	Mean temperature
			Days	*° F.*	*Days*	*° F.*
Dec. 13, 1915	Dec. 16, 1915	Dec. 20, 1915	3½	78	4	52
Dec. 14, 1915	do	Dec. 28, 1915	2½	79	12	52
Dec. 16, 1915	do	Jan. 3, 1916	0		18	[1]52
Feb. 9, 1916	Feb. 12, 1916	Feb. 20, 1916	3½	70	8	51
Feb. 12, 1916	do	Mar. 2, 1916	0		19	53

[1] Approximately 52° F., but not precisely observed; refrigerator temperature ranged from 46° to 60°, but seldom above 56°.

Since the length of the egg stage depends largely, if not entirely, upon the mean temperature at which the hatching is done, an attempt was made to estimate this length by comparing the results shown in Table 1 with the normal temperatures prevailing at Brownsville in the different months of the year. In Table 3 are presented the mean temperatures for the several months of the year, together with the mean maxima and minima, and highest and lowest recorded temperature for each month, all taken from the published climatological data of the Weather Bureau.[5] The various temperatures given are results of observations made at Brownsville for long periods of time; 60 years for the monthly mean temperatures, 21 for the mean maximum and minimum, and 29 for the highest and lowest. The latest observations included, for all classes, were made in 1920.

For the months of December, January, and February the mean temperatures range from 59.4° to 62.9° F., and in Table 1 it is shown that with mean temperatures ranging from 59° to 65° the average duration of the egg stage ranges from 7 to 11 days, with the observed range in either direction slightly exceeding these limits. Apparently it may safely be assumed that at Brownsville in the three months named the eggs of *L. frugiperda* will hatch in from 7 to 11 days or possibly longer. In March the normal temperature is 68.3°, in April, 73.7°; by a similar process of reasoning it may be concluded from data in Table 1 that the approximate incubation period for those months is from 4 to 6 days. Normal temperatures are highest, and not widely different, in June, July, August, and September, ranging from 80.5° to 83.9°; it may therefore be assumed that the incubation period will be about 2 days. For October and November the normal temperatures are 74.6° and 67.5°, respectively, and the period of incubation may be assumed to range from 4 to 6 days.

[5] UNITED STATES DEPARTMENT OF AGRICULTURE, WEATHER BUREAU. SUMMARY OF THE CLIMATOLOGICAL DATA FOR THE UNITED STATES BY SECTIONS. SOUTHERN TEXAS. U. S. Dept. Agr., Weather Bur. Bul. W, ed. 2, v. 1, illus., 1926. (Reprint Sect. 1.)

TABLE 3.—*Average monthly and annual mean, mean maximum, mean minimum, and highest and lowest recorded temperatures at Brownsville, Tex.*

Month	Mean	Mean maximum	Mean minimum	Highest	Lowest	Month	Mean	Mean maximum	Mean minimum	Highest	Lowest
	°F.	°F.	°F.	°F.	°F.		°F.	°F.	°F.	°F.	°F.
January	59.4	70.9	50.1	90	18	August	83.9	94.1	75.2	104	63
February	62.9	72.6	52.3	94	12	September	80.5	91.1	71.8	102	51
March	68.3	78.2	58.2	98	28	October	74.6	85.7	65.2	99	38
April	73.7	83.1	64.1	100	37	November	67.5	77.9	58.1	98	28
May	78.6	87.3	69.9	102	41	December	61.5	71.2	50.8	93	15
June	82.4	91.8	73.5	103	56	Annual	73.1	83.1	63.6	104	12
July	83.8	92.9	74.5	102	57						

DURATION OF THE LARVAL STAGE

The duration of the larval stage was ascertained in experiments on six lots of caterpillars, each lot being hatched on a given date. The six lots totaled 767 caterpillars. The experiments were carried on in the laboratory; those with eggs laid in June and July, 1913, by O. W. Rosewall, and the others by Felix V. Garcia. The resulting pupae were about equally divided between the sexes. In each experiment the females pupated about one-half day earlier, on the average, than the males. The results of these experiments are presented in Table 4.

TABLE 4.—*Duration of larval stage of Laphygma frugiperda as related to attendant mean temperatures, observed at Brownsville, Tex., in the years 1913 to 1916*

Date of hatching	Last date of pupation for lot	Mean temperature, hatching to pupation	Number of larvae	Range of larval period	Average of larval period	Per cent of larvae developing in about the average number of days
		°F.		*Days*	*Days*	
June 16, 1913	June 30, 1913	80	193	11½–13	12	12 days, 57.
July 14, 1913	July 29, 1913	82	226	11 –15½	12	11 to 13 days, 97.
Oct. 31, 1915	Nov. 20, 1915	75	100	15 –20	17	15 to 17 days, 75.
Nov. 24, 1915	Jan. 4, 1916	68	100	32 –41	35	32 to 36 days, 80.
Dec. 14, 1915	Jan. 18, 1916	70	99	25 –35	28	25 to 28 days, 77.
Jan. 2, 1916	Jan. 31, 1916	68	49	25 –29	26	26 to 27 days, 81.

Concerning the influence of temperature on the duration of the larval stage, several points should be considered. There are six instars in the larval stage of this insect, each instar being divided into two periods, an active feeding period and a resting period which occurs before each molt. Temperature influences the length of the inactive periods, low temperatures prolonging them. During the active periods a supply of food is important, but the length of these periods may also be influenced by temperature.

The data of Table 4 indicate that the duration of the larval stage may have been influenced by factors other than temperature. The facts would have been brought out more clearly if the observations had included the durations of the active and inactive periods of each

instar, and if care had been taken to provide a continuous supply of food for all active larvae, and about equal humidity for all molting larvae.

At mean temperatures of 80° and 82° F. the duration of the larval stage was 12 days; this is probably near the minimum duration. At a mean temperature of 75° the duration of the larval stage ranged from 15 to 20 days, with an average of 17 days. At a mean temperature of 70° the duration of the larval stage ranged from 25 to 35 days, with an average of 28 days; and in one experiment at 68° the average was 26 days. Of the 148 caterpillars in these two experiments 83 per cent pupated in from 25 to 28 days. This is probably about the usual length of the entire larval stage at mean temperatures of 68° to 70°.

In the experiment begun November 24, 1915, which was also conducted at a mean temperature of 68° F., the duration of the larval stage ranged from 32 to 41 days, with an average of 35 days. No explanation of this greater number of days is apparent from the records of the experiments.

From the data given in this table in connection with the monthly mean temperatures shown in Table 3, it seems probable that the duration of the larval stage at Brownsville from April to October will range between 12 and 20 days, and will be about 12 days during the two hottest months of the year—July and August. In the colder months of the year, from November to March, the duration of the larval stage ranges from 25 to 41 days, or perhaps more.

DURATION OF THE PUPAL STAGE

The duration of the pupal stage at Brownsville was observed for many individual pupae, and in different months of the year. In these experiments the pupae were confined in 4-ounce tin boxes, as such boxes would hold a large number. A piece of wet blotting paper was usually placed in each box, as excessive dryness seemed to retard the emergence of the moths.

The duration of the pupal stage, from pupation to emergence, for two pupae in December, January, and February, was 34 days, at 61° F., which is near the normal temperature for December and January at Brownsville, as may be ascertained by a little consideration of data in Table 3.

Several experiments, presented in some detail in Table 5, were conducted to get information on the duration of the pupal stage at temperatures below 60° F. The pupae were placed in tin boxes, which were kept in an ordinary household refrigerator. The greatest length of time in the refrigerator was 51 days, at 56°, for pupae which had been 4 days in the laboratory. Unfortunately, none were kept in the refrigerator during the entire length of the pupal period, but the experiments show that the pupae will live at temperatures between 52° and 56°, and that the moths will emerge at these temperatures; further, that the duration of the pupal stage, under conditions encountered, may be as long as 55 days.

TABLE 5.—*Duration of pupal stage of Laphygma frugiperda at recorded mean temperatures of laboratory and refrigerator, observed at Brownsville, Tex., between November 19, 1915, and February 25, 1916*

Date of pupation	Date pupae placed in refrigerator	Date of emergence of moths	Number of moths	Time kept in laboratory	Mean temperature of laboratory	Time kept in refrigerator	Mean temperature[1] of refrigerator
				Days	° *F.*	*Days*	° *F.*
Nov. 19, 1915	Nov. 30, 1915	Dec. 16, 1915	1	11	66	16	52
Do	do	Dec. 20, 1915	1	11	66	20	52
Do	do	Dec. 21, 1915	1	11	66	21	52
Do	do	Dec. 24, 1915	2	11	66	24	52
Nov. 22, 1915	do	Dec. 21, 1915	1	8	66	21	52
Do	do	Dec. 23, 1915	1	8	66	23	52
Do	do	Dec. 24, 1915	1	8	66	24	52
Do	do	Dec. 25, 1915	1	8	66	25	52
Do	do	Dec. 31, 1915	3	8	66	31	52
Feb. 25, 1916	Feb. 29, 1916	Apr. 17, 1916	2	4	74	48	56
Do	do	Apr. 20, 1916	1	4	74	51	56

[1] The temperature in the refrigerator ranged from 46° to 60° F., but was seldom above 56°. The mean temperature was not precisely ascertained during December, but was near 52°.

It had been observed in experiments on pupation that of specimens of both sexes pupating at the same time the females frequently emerged a day or so earlier than the males; accordingly, pupae of the respective sexes were separately observed, some in the laboratory and some in the insectary, with results presented in Table 6. In all, records of 874 pupae are there summarized, the average length of pupation of each lot being given, and averages of the daily mean temperatures in the several cases. In a few instances, to show the average range of temperature of a lot, the average maximum and average minimum temperatures of a lot are given. In the insectary the average range of temperature was high, being about 20°; in the laboratory it was only from 4° to 8°. Besides the average length of pupation for each lot, the maximum and minimum are given in most cases. The several observers by whom the records were made are named in a footnote.

TABLE 6.—*Duration of pupal stage of Laphygma frugiperda, at recorded mean temperatures of laboratory or insectary, observed at Brownsville, Tex., 1913–1916, (summary of observations on 874 individual pupae)*

Average temperature			Male pupae			Female pupae		
Mean	Maximum	Minimum	Individuals	Range of duration of period	Average duration of period	Individuals	Range of duration of period	Average duration of period
° *F.*	° *F.*	° *F.*	*Number*	*Days*	*Days*	*Number*	*Days*	*Days*
[1] 65	76	55	2	31	31	7	31–32	31½
[2] 65	68	60				3	19–21	20
[2] 66			28	18 –23	21	74	16–23	18½
[2] 67			67	17 –22	19½	43	17–21	18½
[2] 68			9	19 –22	20	3	17–21	18
[2] 69			16	17 –21	19			
[2] 70	73	67	13	16 –18	17	13	15–16	16
[2] 71						18	14–15	14
[2] 72	74	69	1		14	2	14	14
[1] 72	82	63	8		17			
[3] 80	82	78	13	8 –10½	9	22	7–10	8
[4] 81			99	7 – 8½	8	94	7– 8½	7½
[5] 84½	86½	82	50	6½– 8¼	7½	63	6– 7½	6.7
[4] 83½			115	6 –10	7.2	111	6– 9	6.3

[1] Observed by C. L. Scott, in insectary, January and February, 1914.
[2] Observed by F. V. Garcia, in laboratory, at intervals from Nov. 17, 1915, to Feb. 21, 1916.
[3] Observed by R. A. Vickery, in laboratory, from May 30 to June 10, 1914.
[4] Observed by O. W. Rosewald, in laboratory, from June 28 to July 8, 1913.
[5] Observed by C. L. Scott, in laboratory, from June 29 to July 14, 1914.

The experiments considered in the preceding paragraph concern the duration of the pupal stage when the pupae are confined in a humid atmosphere within tin boxes kept in the laboratory or the insectary. Under natural conditions pupation occurs in the soil, which has a rather uniform temperature. But the temperature of the soil 1 or 2 inches beneath the surface would depend on the amount of sunlight received at that point. As pupation usually occurs in soil that is shaded by vegetation, it is probable that the average pupa which produces a moth is subject to temperatures not far from the mean temperatures in the shade for the duration of the pupal period.

Considering the data given in Tables 5 and 6 in connection with the monthly mean temperatures at Brownsville, to be found in Table 3, the following conclusions are reached concerning the duration of the pupal stage in each month of the year at that locality: The stage ranges from 7 days in summer to 34 or more in the winter. In July and August it would be about 7 days; in May and September, from 8 to 9 days; in April and October, about 14 days; in March and November, from 18 to 30 days; in December, January, and February from 31 to 34 days, or more.

NUMBER OF GENERATIONS DURING THE YEAR

No definite number of generations of *Laphygma frugiperda* can be observed in the field at Brownsville, as all stages of the insect can be found at any time. From the tables on the duration of the egg, larval, and pupal stages the approximate length of the generations for the different seasons can be calculated and the probable number of generations during a year estimated.

During the hot months, May, June, July, August, and September, at Brownsville the monthly normal mean temperatures (Table 3) range between 79° and 84° F. At these temperatures the length of the egg stage is from 2 to 3 days, that of the larval stage from 11 to 13 days, and that of the pupal stage from 7 to 9 days, a total of 20 to 25 days, to which should be added 3 days of the adult stage which intervene before eggs are laid. This makes 23 to 28 days from the time eggs are laid by moths of one generation to the time eggs are laid by moths of the next generation, and about six generations could be completed during these months.

In March and April and in October and November the monthly normal mean temperatures range from 68° to 74° F., and the duration of the different stages varies considerably at these temperatures. The length of the egg stage ranges from 4 to 6 days, that of the larval stage from 17 to 35 days, and that of the pupal stage from 14 to 18 days. From these figures it appears that the length of a generation might range during these months from 38 to 62 days, and that from one to one and one-half generations could be completed during October and November, and the same number during March and April.

During the winter months the normal monthly mean temperatures range from 59° to 63° F., and at these temperatures the length of the egg stage is from 8 to 12 days, the larval stage 41 days or more, and the pupal stage about 34 days. The total length of a generation at these temperatures appears to be between 80 and 90 days, and only one generation could be completed during the cold months.

From the previous paragraphs it appears that the total number of generations during the year at Brownsville ranges from 9 to 11. There

are probably never less than 9 generations, and it is doubtful if more than 11 could be completed, even in favorable years.

PARASITES OF LAPHYGMA FRUGIPERDA

THE PARASITISM AS OBSERVED AT BROWNSVILLE

Early in the study of *Laphygma frugiperda* at Brownsville it was observed that this species is sometimes destroyed in large numbers by parasites. Accordingly, studies on the life history and habits of the parasites were undertaken, and numerous collections of larvae were made in order to determine the percentage of parasitism and to ascertain which species of parasites were effective.

Egg masses were collected at various times for the purpose of rearing true egg parasites, but none were reared. Probably the deposition of down on the egg mass by the moth largely protects the eggs from parasites. The collections of eggs, however, were not numerous enough to warrant the statement that Laphygma eggs are not parasitized at Brownsville. The most common parasite of Laphygma at Brownsville, *Chelonus texanus*, oviposits in the egg but the adult emerges from the larva and not from the egg. C. L. Scott observed an adult lady beetle, *Ceratomegilla fuscilabris* (Muls.) eating eggs of Laphygma, and there may be other predacious insects that feed on the eggs.

Archytas piliventris attacks the larva, but emerges from the pupa. This species was reared in large numbers from the collections of caterpillars. There also may be parasites that oviposit in the pupae, but no collections of pupae were made, and no information was acquired on this point.

Caterpillars to the number of 16,162 were collected in the years 1911 to 1916, inclusive. The most extensive collections were made in 1913 and 1914, about 12,000 specimens being taken during those two years. Only 259 caterpillars were collected in 1911 and 82 in 1912.

The work of rearing these caterpillars is tedious, because it is necessary to take precautions both to prevent them from killing one another and to prevent the spread of disease among them. It is also necessary to free their food from tachinid larvae. When brought to the laboratory the caterpillars were separated roughly into two lots; small caterpillars, of the fourth instar and under, most of them being in the third and fourth, and large caterpillars, of the fifth and sixth instars. Those of each lot were isolated in 1-ounce tin boxes, and fed on corn leaves which had been wiped with a cloth to remove the larvae of the tachinid parasite *Archytas piliventris*. The boxes were sterilized by dry heat in an oven over a gasoline stove. The parasites of each lot were reared and identified.[6] The results of these rearings are presented in Tables 7 and 8, the numbers of host larvae destroyed by the several parasites, and those which otherwise failed to reach maturity, being arranged by months to show the relative abundance of each species of parasite in the course of the different months when the host larvae were collected.

[6] The writer is indebted to R. A. Cushman and A. B. Gahan for identifications of the Hymenoptera, and to W. R. Walton for identifications of the Diptera.

TABLE 7.—*Larvae of Laphygma frugiperda killed by certain parasites reared from them at Brownsville, Tex., March 14, 1911, to June 16, 1916*

[Summary of collections of larvae of the fourth instar and under, arranged according to the months in which the collections were made]

Month when collected	Larvae collected	Larvae killed by the parasites named												Larvae killed by fungus Beauveria globulifera (Speg.)	Larvae that died of injury or disease	Moths emerging
		Hymenoptera									Tachinidae					
		Chelonus texanus Cresson	Meteorus laphygmae Viereck	Sagaritis dubitatus (Cresson)	Apanteles marginiventris (Cresson)	Euplectrus platyhypenae Howard	Ophion bilineatus Say	Neopristomerus appalachianus Viereck	Rogas laphygmae Viereck	Zele melleus (Cresson)	Frontina archippivora Soudder	Archytas piliventris V. d. W.	Total			
	No.	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*
January	330	16	3	1	5	1	----	----	----	----	----	----	26	28	103	173
March	122	31	----	----	----	----	----	----	----	----	----	----	32	15	36	39
April	833	87	41	109	61	1	----	11	5	----	----	16	331	28	38	436
May	1,653	446	50	155	39	7	3	23	36	----	----	17	776	44	119	714
June	1,452	631	17	17	----	4	----	20	3	----	2	----	694	----	416	342
July	925	656	12	3	----	2	----	14	----	----	1	----	688	2	105	130
August	382	187	----	----	----	----	----	1	----	----	----	1	189	----	32	161
September	1,169	472	29	----	19	----	2	1	----	----	----	4	527	----	70	572
October	1,345	361	75	----	13	----	1	1	----	1	----	22	474	24	96	751
November	542	100	38	----	9	2	----	2	----	----	----	16	167	67	76	232
December	288	6	5	----	11	----	----	----	----	----	----	----	22	31	64	171
Total	9,041	2,993	270	285	157	17	6	74	44	1	3	76	3,926	239	1,155	3,721
Per cent of total	------	33	3	3	2	----	----	1	½	----	----	1	43½	2.6	13	41

TABLE 8.—*Larvae of Laphygma frugiperda, killed by certain parasites reared from them at Brownsville, Tex., March 14, 1911, to June 16, 1916*

[Summary of collections of large larvae, fifth and sixth instars arranged according to the months in which the collections were made]

Month when collected	Larvae collected	Larvae killed by the parasites named							Larvae killed by fungus Beauveria globulifera (Speg.)	Larvae that died of injury or disease	Moths emerging
		Hymenoptera				Tachinidae					
		Meteorus laphygmae Viereck	Euplectrus platyhypenae Howard	Ophion bilineatus Say	Zele melleus (Cresson)	Frontina archippivora Soudder	Archytas piliventris V. d. W.	Total			
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
January	127	6	----	2	----	----	1	9	14	19	85
March	75	----	----	----	----	----	13	13	1	11	50
April	824	41	29	10	----	1	156	237	9	100	478
May	759	18	64	3	----	1	76	162	9	71	517
June	955	52	17	5	----	1	105	180	----	108	667
July	118	7	2	----	----	----	----	9	----	55	54
August	255	----	----	1	----	----	----	1	----	15	239
September	574	54	1	15	----	----	25	95	----	37	442
October	2,047	52	1	74	2	----	250	379	19	177	1,472
November	894	10	1	8	----	----	110	129	12	187	586
December	493	2	2	2	----	----	21	27	38	186	242
Total	7,121	242	117	120	2	3	757	1,241	102	966	4,812
Per cent of total	------	3.4	1.6	1.7	----	----	10.6	17.4	1.4	13.6	67.6

The results of the rearings of parasites from small larvae, of which 9,041 were collected, are presented in Table 7. Nine species of Hymenoptera were reared, of which five were of the family Braconidae, three of the family Ichneumonidae (subfamily Ophioninae), and one species of the family Eulophidae; there were two species of Diptera of the family Tachinidae, and one common fungous disease, *Beauveria globulifera*. About 13 per cent of the larvae died from undetermined causes, classified in Table 7 as injury or disease. Some of these may have been parasitized, but they were not dissected to determine this point. As already stated, *Chelonus texanus* oviposits in the egg and is the most important parasite of Laphygma at Brownsville, as it destroyed 33 per cent of all the small caterpillars; this is more than the total destroyed by all of the other species. Next in importance to Chelonus is *Meteorus laphygmae*, which destroyed 3 per cent of the caterpillars. *Sagaritis dubitatus* also was of some importance during April and May. None of the other species appear to be important, so far as these four instars are concerned. Three species, *Ophion bilineatus*, *Euplectrus platyhypenae*, and *Archytas piliventris*, attack larger larvae (Table 8), and their true status is not shown by Table 7.

The results of the rearings of parasites from large caterpillars are summarized in Table 8. Of the fifth and sixth instars 7,121 caterpillars were collected, and from these were reared four species of Hymenoptera, of which two were of the family Braconidae, one of the family Ichneumonidae (subfamily Ophioninae), and one of the family Eulophidae; and two species of Diptera of the family Tachinidae. The fungus *Beauveria globulifera* also infested these caterpillars. About 13 per cent of the large caterpillars died from undetermined causes classified as injury and disease. *Meteorus laphygmae* destroyed about the same percentage of large caterpillars (Table 7) as of caterpillars of the earlier instars. As it oviposits in larvae of the first or second instar and emerges from the caterpillars of the fifth instar, the percentage of larvae listed as killed in Table 7 should be about the same as the percentage listed as killed in Table 8. Nothing was learned about *Zele melleus* or *Frontina archippivora*. The other species, *Ophion bilineatus*, *Euplectrus platyhypenae*, and *Archytas piliventris*, attack large larvae and are important because they destroy some of the caterpillars that escape the parasites listed in Table 7. Of the three last-mentioned parasites *A. piliventris* is the most important, as it destroyed about 10 per cent of all of the large caterpillars, or more than the total destroyed by the other five species listed in Table 8.

In order to make clear the relative importance of the parasites, the writer has prepared Table 9 from the data contained in Tables 7 and 8. Three columns, derived from Table 7, compare the percentages of larvae destroyed by *Chelonus texanus* and *Meteorus laphygmae*, and the percentages destroyed by a group of five other parasites, *Sagaritis dubitatus*, *Apanteles marginiventris*, *Rogas laphygmae*, *Neopristomerus appalachianus*, and *Zele melleus* combined. These parasites all attack the early stages, and all except Meteorus and Chelonus emerge from the host before it reaches the fifth instar. The percentages in these three columns are totaled in column 5. In columns 6, 7, and 8 are given the percentages of larvae destroyed by the three species which attack the later instars of the host. In experiments on life history

Ophion oviposited in small caterpillars of the second, third, and fourth instars, but very few specimens were reared from the small caterpillars collected; and because it emerges from the sixth instar the percentage of larvae it destroyed is included with the percentages destroyed by parasites attacking larvae in the later instars. The percentages under these three species were derived from data in Table 8 and are totaled in column 9. Column 10 shows the total percentage of parasitism to which the species might be subject in any cornfield, based on a percentage of the total number of caterpillars hatching from the eggs.

TABLE 9.—*Percentages of larvae of Laphygma frugiperda destroyed by several named species of parasites, and the total percentage of larvae that may be destroyed by parasites*

Month in which larvae were collected	Larvae of first four instars destroyed by parasites named				Larvae of fifth and sixth instars destroyed by parasites named				Larvae that may be destroyed by all parasites
	Chelonus texanus Cresson	Meteorus laphygmae Viereck	Five other species of parasites[1]	Total	Euplectrus platyhypenae Howard	Ophion bilineatus Say	Archytas piliventris V. d. W.	Total	
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
January	5	1	2	8		2	1	3	11
March	25		1	26			17	17	39
April	10	5	22	37	4	1	19	24	52
May	27	3	15	45	8		10	18	56
June	43	1	3	47	2	1	11	14	54
July	71	1	2	74	2			2	75
August	49			49					49
September	40	2	2	44		3	4	7	48
October	27	6	1	34		4	12	16	45
November	19	7	2	28		1	12	13	37
December	2	2	4	8			4	4	12

[1] This column shows the total percentage of larvae destroyed in each month by the parasites *Sagaritis dubitatus, Apanteleles marginiventris, Rogas laphygmae, Neopristomerus appalachianus,* and *Zele melleus.*

As shown in the fifth column of Table 9, the proportion of larvae of the first four instars destroyed in the winter months is small, being about 8 per cent, whereas in March it is 26 per cent, and from that time it increases gradually as the weather becomes warmer, until it reaches 74 per cent, in July; it then decreases until it reaches 28 per cent, in November. This seasonal variation seems to be due to *Chelonus texanus,* which is numerous during June, July, August, and September. The activity of Chelonus appears to be reduced in April and May, but during these months there is a corresponding increase in the percentages for the aggregate of the five parasites shown in the fourth column, which indicates a possible conflict between some of these species and Chelonus. The fact that these parasites, especially Chelonus, destroy a rather large percentage, 28 to 47, of these caterpillars in April, May, and June, and in September, October, and November, the months in which corn is attacked at Brownsville, is of importance, as this percentage of parasitism may be sufficient to prevent excessive injury to the corn crop.

The next to the last column of Table 9 shows the percentage of large larvae destroyed by *Euplectrus platyhypenae*, *Ophion bilineatus*, and *Archytas piliventris*. This column shows important percentages for March, April, May, June, October, and November, which are the months during which young corn 1 to 4 feet high may be found in the field. But as caterpillars infested with these parasites reach a large size, those attacked by Archytas and Ophion being able to complete six instars, they continue feeding voraciously on the plants; the attack of the parasites therefore affords little protection to the corn plants, although the number of moths that may subsequently emerge is reduced.

The last column of Table 9 shows the total percentage of caterpillars that may be destroyed by all of the parasites listed. The percentages in that column are obtained for each month by subtracting the number in the fifth column from 100, multiplying the remainder by the percentage in the next to the last column, and adding this percentage to the percentage in the fifth column. The percentage of larvae destroyed by all parasites as shown in the last column is lowest in the winter and highest in July; it increases from about 11 per cent in January to 75 per cent in July, after which it decreases, reaching 12 per cent in December. These percentages are due principally to Chelonus, except in April and May, when Archytas and other species destroy more than 50 per cent of the parasitized caterpillars.

PARASITES IN TEXAS, OKLAHOMA, KANSAS, LOUISIANA, AND ARKANSAS

In addition to the collections made in the vicinity of Brownsville 3,424 caterpillars were collected in other parts of Texas and in other States and sent to Brownsville so that their parasites might be reared. The numbers of parasites reared from the larvae found in each locality, with the number, in a single instance, of larvae killed by the fungus *Beauveria globulifera*, and the additional numbers of larvae that died of injury or disease, are presented in Table 10. Most of the caterpillars were collected in Texas, especially along the Gulf coast, but a few were taken in Oklahoma, Kansas, Louisiana, and Arkansas. *Chelonus texanus* appears to be the most important of the Laphygma parasites in other parts of Texas, as well as at Brownsville. Of the other parasites that attack the early stages of the host *Apanteles marginiventris* and *Neopristomerus appalachianus* were the only species commonly reared. *Ophion bilineatus* was reared in comparatively large numbers from collections made along the Gulf coast, and appears to be more important in some localities than it is around Brownsville. *Archytas piliventris* from only three localities along the Gulf coast was reared, and it may not be widely distributed or so important in other localities as it is in the Brownsville section.

These collections do not reveal any parasites of Laphygma not found at Brownsville, and the list contains all of the parasites of this species known to be in that locality. To obtain more accurate information as to the relative importance of these parasites elsewhere than in Brownsville it would be necessary to make more numerous collections in each locality during each month and so ascertain the seasonal occurrence of the various species.

TABLE 10.—*Parasites reared from larvae of Laphygma frugiperda, collected at points in Texas outside the lower Rio Grande Valley, and in Louisiana, Arkansas, Oklahoma, and Kansas. (Collections made during 1912, 1914, 1915, and 1916, and reared at Brownsville, Tex.)*

Locality in which larvae were collected	Larvae collected	Larvae killed by the parasites named														
		Hymenoptera									Tachinidae		Total	Larvae killed by fungus Beauveria globulifera (Speg.)	Larvae that died of injury or of disease	Moths emerging
		Chelonus texanus Cresson	Meteorus laphygmae Viereck	Sagaritis dubitatus (Cresson)	Apanteles marginiventris (Cresson)	Euplectrus platyhypenae Howard	Ophion bilineatus Say	Neopristomerus appalachianus Viereck	Rogas laphygmae Viereck	Zele melleus (Cresson)	Frontina archippivora Scudder	Archytas piliventris V. d. W.				
	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.
Kingsville, Tex	40				3								3		2	35
Odem, Tex	274						1						1			273
Taft, Tex	38	13											13		3	22
Beeville, Tex	339	32			1	4	28					7	72		41	226
Victoria, Tex	421	57			2		30	12			2	3	106		47	268
Cuero, Tex	51	17			1								18		3	30
Yoakum, Tex	93	28					1						29		9	55
Bay City, Tex	27	1			2								3		3	21
Brazoria, Tex	485				4		81						85	5	10	385
Wharton, Tex	66						2						2		2	62
Sugarland, Tex	134						84					8	92			42
Beaumont, Tex	41	21											21			20
College Station, Tex	114	1			4			1					6		7	101
Whittaker, Tex	57	24			1		1	3					29			28
Kyle, Tex	35							3					3		3	29
Waco, Tex	539	212			1			4					217		49	273
Ennis, Tex	30	14											14			16
Dallas, Tex	50	13						2					15		11	24
Van Alstyne, Tex	61	22											22		5	34
Sulphur Springs, Okla	100				6			1					7		6	87
Wellington, Kans	21			1	1								2			19
Hunnewell, Kans	36				10								10			26
Shreveport, La	345	191	8					1	2	1			203		124	18
Morrilton, Ark	24	5				1							6			18
Texarkana, Ark	3					1							1			2
Total	3,424	651	8	1	36	6	228	27	2	1	2	18	980	5	325	2,114

OUTLINE OF PARASITISM

The following outline has been prepared to aid the reader in understanding the relationships of the primary and secondary parasites to each other and to the host.

HYMENOPTERA

PRIMARY PARASITES

Ovipositing in the egg:

Chelonus texanus Cresson. Emerges from fifth-instar larvae.[7]

Ovipositing in first-instar caterpillars:

Apanteles marginiventris (Cresson). Emerges from fourth-instar larvae.

Ovipositing in first-instar or second-instar caterpillars:

Meteorus laphygmae Viereck. Emerges from fifth-instar larvae.

Rogas laphygmae Viereck. Emerges from fourth-instar larvae.

[7] The stage in which infested caterpillars die was not worked out by counting the number of molts. It was decided for each species of parasite on the appearance of the caterpillar and by the head measurements. Infested larvae are smaller and have narrower heads than normal larvae of the same age.

Ovipositing in first-instar or second-instar caterpillars—Contd.
Zele melleus Cresson (Cresson).[8] Emerges from fourth-instar larvae.
Sagaritis dubitatus (Cresson). Emerges from fourth-instar larvae.
Neopristomerus appalachianus Viereck.[8] Emerges from fourth-instar larvae.
Ovipositing on or in large caterpillars:
Ophion bilineatus Say. Emerges from sixth-instar larvae.
Euplectrus platyhypenae Howard. An external parasite that destroys caterpillars of the fourth, fifth or sixth instar.

SECONDARY PARASITES

Spilochalcis pallens (Cresson). Reared from *Meteorus laphygmae* and *Rogas laphygmae*.
Spilochalcis torvina (Cresson). Reared from *M. laphygmae*.
Dibrachys meteori Gahan. Reared from *M. laphygmae*, *Sagaritis dubitatus*, and *R. laphygmae*.
A species of Eupteromalus. Reared from *S. dubitatus*.
Eupelminus meteori Gahan. Reared from *M. laphygmae*.
Tetrastichus euplectri Gahan. Reared from *Euplectrus platyhypenae*.
Tetrastichus dolosus Gahan. Reared from *E. platyhypenae*.
A species of Hemiteles. Reared from *M. laphygmae*, *R. laphygmae*, *S. dubitatus*, and *Apanteles marginiventris*.
A species of Mesochorus. Reared from *M. laphygmae*.
Myrmicomorpha perniciosa Viereck. Reared from *M. laphygmae* and *R. laphygmae*.

DIPTERA

Emerging from large caterpillars (fifth or sixth instar):
Frontina archippivora Scudder.
Emerging from the pupa:
Archytas piliventris Van der Wulp.

FUNGI

Beauveria globulifera.

CHELONUS TEXANUS CRESSON[9]

The parasite *Chelonus texanus*, as has been indicated in Table 7, was reared from 33 per cent of all the small caterpillars collected in the vicinity of Brownsville. This figure probably approximates the average percentage of caterpillars parasitized by it, as the collections were numerous and were made in the course of several years in various localities within 60 miles of Brownsville. It appeared to be most effective in July and August, infesting approximately 65 per cent of all the small caterpillars collected in those two months.

DISTRIBUTION

Chelonus texanus is the most important parasite of *Laphygma frugiperda* in the Gulf Coast States. It was reared at Brownsville from caterpillars collected by members of the staff of the Brownsville field station (Table 10) at Taft, Beeville, Victoria, Cuero, Yoakum, Bay City, Beaumont, College Station, Whittaker, Waco, Ennis, Dallas, and Van Alstyne, Tex.; Shreveport, La.; and Morrilton, Ark. It

[8] Oviposition by Zele and Neopristomerus was not observed by the writer.
[9] A solitary endoparasite, Hymenoptera, Braconidae.

appears to be as effective in some of these localities as it is at Brownsville, 40 per cent of the caterpillars collected at Waco, and 55 per cent of those collected at Shreveport being infested by this parasite.

OVIPOSITION

The female of *Chelonus texanus* oviposits in the egg of its host.[10] This fact was first called to the writer's attention by T. E. Holloway, who observed the species ovipositing in eggs of *Heliothis obsoleta* on corn at Brownsville in the spring of 1912. During May, 1912, the writer observed oviposition in the eggs of *Laphygma frugiperda* on corn in the field. At Brownsville this species had frequently been reared from Laphygma, but no clue to its life history had been obtained previous to Mr. Holloway's observations.

These parasites, when placed in breeding cages with egg masses, soon find the eggs and begin ovipositing. The writer observed one caged female which spent an hour on one egg mass. She worked over the egg mass apparently at random from one side to the other and back again, skipping some of the eggs, and thrusting her ovipositor between the eggs of the upper layer in order to reach those of the lower. She oviposited directly in the egg, the oviposition for each egg occupying about four seconds.

THE LARVAL STAGE

The length of the incubation period was not ascertained. The length of time that elapsed from oviposition to the spinning of the cocoon (Table 11) ranged from 11 days, in August, to 22 days, in October. From the date of the first observed oviposition, August 7, to the spinning of two cocoons on September 11, an interval for which the mean temperature was 83° F., the average time from the oviposition to the spinning was 13 days, the separate times being 11 days for two cocoons, 13 days for seven, and 16 days for two. At a mean temperature of 78° the time so elapsing was 13 days for 15 cocoons and 18 days for 18 cocoons, the average being about 15½ days. Two cocoons were spun on October 31, 22 days after oviposition, the mean temperature during that interval being 71°.

TABLE 11.—*Interval of time from oviposition to the spinning of the cocoon of Chelonus texanus, at Brownsville, Tex., August to October, 1913*[a]

Date of oviposition	Date cocoons were spun	Number of cocoons	Interval	Mean temperature	Date of oviposition	Date cocoons were spun	Number of cocoons	Interval	Mean temperature
			Days	*° F.*				*Days*	*° F.*
Aug. 7	Aug. 18	1	11	84	Sept. 9	Sept. 22	15	13	78
Aug. 15	Aug. 26	1	11	83	Do	Sept. 27	18	18	78
Aug. 26	Sept. 8	7	13	83	Oct. 9	Oct. 31	2	22	71
Do	Sept. 11	2	16	83					

[a] These data are tabulated from experiments by C. L. Scott and E. G. Smyth.

[10] PIERCE, W. D., and HOLLOWAY, T. E. NOTES ON THE BIOLOGY OF CHELONUS TEXANUS CRESS. Jour. Econ. Ent. 5:425–428. 1912.

METHOD OF SPINNING THE COCOON

The cocoons were not observed in the field, but it is probable that they are built within a cell in the soil. In large cages with soil in the bottom the infested caterpillars of the fifth instar[11] leave their host plant and enter the soil, where they form a cell as if they were preparing to pupate. When the infested larvae are kept in tin boxes they form the cell by fastening together leaves or trash with silk threads.

The Chelonus larva emerges within this cell and builds its cocoon. It can not complete its cocoon unless it is inclosed in a cell. When the infested caterpillars were kept in tin boxes they often built only a nest, which was open on one side, and the Chelonus larvae were unable to complete their cocoons within this nest. The parasite larvae frequently pupated in the tin boxes without completing the cocoon.

The details of the construction of the cocoon were not observed. The cocoons, as built in the boxes, were white in color and oval in general outline. They were not smooth on the outside but frequently had flat surfaces or projections, depending upon the surroundings.

THE PUPAL STAGE

The parasite larvae pupate soon after the cocoon is completed. The time spent in the pupal stage ranged (Table 12) from 7 days in August, at a mean temperature of 83° F., to 14 days in April, at a mean temperature of 73°. No data were obtained as to the length of the pupal stage in the colder months.

TABLE 12.—*Interval of time from the spinning of the cocoon to the emergence of the adult of Chelonus texanus at Brownsville, Tex., 1913 and 1916*

Date cocoons were spun	Date adults emerged	Number of adults	Interval	Mean temperature	Date cocoons were spun	Date adults emerged	Number of adults	Interval	Mean temperature
			Days	° *F.*				*Days*	° *F.*
June 2, 1913	June 10, 1913	2	8	80	Aug. 26, 1913	Sept. 2, 1913	2	7	84
Aug. 18, 1913	Aug. 25, 1913	1	7	83	Apr. 3, 1916	Apr. 17, 1916	6	14	73

SUMMARY OF DEVELOPMENTAL PERIOD

Chelonus texanus oviposits in the egg of its host, and the parasitic larva develops within and emerges from the caterpillar. Infested caterpillars of the fifth instar enter the soil and construct a cell, within which the parasite emerges and builds its cocoon.

The time elapsing from oviposition to the emergence of the adult (Table 13) ranged in the experiments at Brownsville from 18 to 28 days in 1912 and 1913, when the parasites were reared in lantern-globe cages over pots of soil.

[11] The number of times infested caterpillars molt was not observed. When such caterpillars enter the ground they are about the size of uninfested fourth-instar caterpillars. But infested larvae are smaller than uninfested larvae of the same age, and if larvae infested with Chelonus should pass through five molts and reach the sixth instar, the reason why they enter the soil as if preparing for pupation would be made clear.

TABLE 13.—*Interval of time from oviposition to the emergence of the adult of Chelonus texanus at Brownsville, Tex., in 1912, 1913, and 1914* [1]

Date of oviposition	Date adults emerged	Number of adults	Interval	Mean temperature	Date of oviposition	Date adults emerged	Number of adults	Interval	Mean temperature
1912	1912		*Days*	° *F.*	1913	1913		*Days*	° *F.*
July 18	Aug. 9	2	22	83	Sept. 9	Oct. 7	4	28	79
1913	1913				1914	1914			
Aug. 7	Aug. 25	1	18	84	May 22	June 10	3	19	80
Aug. 15	Sept. 2	2	18	83	Do	June 11	30	20	80
Aug. 26	Sept. 17	1	22	82	Do	June 12	22	21	80
Do	Sept. 18	3	23	82	Do	June 13	7	22	80
Do	Sept. 19	2	24	82	Sept. 8	Oct. 7	22	29	80

[1] Experiments in 1912 and 1913 performed by C. L. Scott and E. G. Smyth, using cages of lantern globes over pots of soil.

PARTHENOGENESIS

One unmated female Chelonus oviposited in eggs of Laphygma on August 15, 1913, and 37 adult Chelonus were reared later from these eggs. The sex of these adults was not recorded. C. L. Scott reared 52 adults, all males, from one experiment, but does not state that an unmated female was used. It appears that this insect can reproduce parthenogenetically, and probably the progeny of unmated females are males.

NUMBER OF PROGENY FROM ONE FEMALE

From one egg mass which had been caged with a single female 63 adults, and from another egg mass 74 adults, were reared. C. L. Scott reared 52 males from one egg mass which had been caged with a single female.

SEASONAL HISTORY

Chelonus texanus was reared from caterpillars of *Laphygma frugiperda* collected in the vicinity of Brownsville in every month of the year except February. No collections were made in February.

The Chelonus adults emerge just before the moths of Laphygma emerge, so the length of a generation in this parasite corresponds to that of Laphygma. The parasite is active throughout the year at Brownsville and probably passes through about 12 generations.

OTHER HOSTS OF CHELONUS TEXANUS

At Brownsville *Chelonus texanus* was reared from *Laphygma exigua* Hbn., *Heliothis obsoleta* (Fab.), and one or more species of Prodenia (see footnote 30, p.56).

PARASITES AND PREDACIOUS ENEMIES

Cocoons of this parasite were not collected in the field for the purpose of rearing secondary parasites, and therefore the writer can not say whether or not it has any parasites. No predacious insects were observed feeding upon it, but, as lady beetles sometimes eat the eggs of Laphygma, they probably destroy a small percentage of the eggs that are infested with Chelonus.

APANTELES MARGINIVENTRIS (CRESSON)[12]

Less than 2 per cent of all small caterpillars collected were parasitized by Apanteles (Table 7), but 2 per cent is probably an undervaluation of the importance of this species, because Apanteles emerges from caterpillars of the fourth instar, and, because of the smallness of the infested larvae, the larger uninfested individuals are more likely to be selected in making collections. To obtain accurate information concerning the importance of this parasite and concerning the importance of *Sagaritis dubitatus* and *Rogas laphygmae*, special collections should be made of caterpillars that are near the end of the second instar.

DISTRIBUTION

This species appears to have a wide distribution in the Southern States. It was reared at Brownsville from Laphygma caterpillars collected by members of the staff of the field station there (Table 10), at Kingsville, Beeville, Victoria, Cuero, Bay City, Brazoria, College Station, Whittaker, and Waco, in Texas; Sulphur Springs, in Oklahoma; and Wellington and Hunnewell, in Kansas.

OVIPOSITION

In the laboratory, female Apanteles were observed to oviposit readily in Laphygma caterpillars of the first instar; they oviposit soon after the caterpillars hatch from the egg, and before they disperse. The female parasite thrusts her ovipositor into the caterpillars and withdraws it immediately. She may run over a caterpillar and oviposit with scarcely a stop.

THE LARVAL STAGE

The time occupied by the egg stage was not ascertained. The interval from oviposition to the emergence of the larva from the host (Table 14) appeared to vary considerably, even for different larvae in the same experiment. In June, in one experiment, it ranged from 8 to 11 days, with an average of 9 days, at a mean temperature of 82°, and in another experiment in June the interval was 7 days, at a mean temperature of 80°. In October the interval ranged in two combined experiments from 7 to 9 days, with an average of 8 days, at mean temperatures of 75° to 77°. In another experiment, in the same month, the interval ranged from 10 to 13 days, with an average of 11.4 days, at mean temperatures of 73° to 75°. In one experiment in November the interval ranged from 10 to 14 days, with an average of 12 days, at a mean temperature of 76°.

The shortest length of time from oviposition to the emergence of the parasitic larva from the host caterpillar recorded in these experiments was 7 days, at a mean temperature of 77°, and the longest time was 14 days, in one case at a mean temperature of 68° and in another case at a mean temperature of 76°.

[12] A solitary endoparasite, Hymenoptera, Braconidae.

TABLE 14.—*Interval of time from oviposition to the spinning of the cocoon of Apanteles marginiventris, at Brownsville, Tex., in 1913 and 1914*

Date of oviposition	Date cocoons were spun	Number of cocoons	Interval	Mean temperature	Date of oviposition	Date cocoons were spun	Number of cocoons	Interval	Mean temperature
1913	1913		*Days*	° *F.*	1914	1914		*Days*	° *F.*
Oct. 30	Nov. 13	3	14	68	Oct. 17	Oct. 26	3	9	76
Nov. 21	Dec. 1	1	10	76	Oct. 18	Oct. 25	3	7	77
Do	Dec. 3	2	12	76	Do	Oct. 26	6	8	76
Do	Dec. 5	1	14	76	Do	Oct. 27	6	9	75
					June 3	June 10	28	7	80
1914	1914				June 10	June 18	18	8	82
Oct. 14	Oct. 24	5	10	75	Do	June 19	21	9	82
Do	Oct. 25	3	11	74	Do	June 20	5	10	82
Do	Oct. 26	2	12	74	Do	June 21	5	11	82
Do	Oct. 27	4	13	73					
Oct. 17	Oct. 24	3	7	77	1915	1915			
Do	Oct. 25	12	8	77	Nov. 3	Nov. 16	4	13	76

The larva of *Apanteles marginiventris*, which is solitary, emerges from Laphygma caterpillars of the fourth instar. The infested caterpillars, which are retarded in growth and remain smaller than normal larvae of the same age, are not killed outright, but live a few hours after the parasite emerges.

THE COCOON

The method of spinning the cocoon was not observed. The cocoons are small, white, smooth, opaque, and of a long, oval shape. They may be found on the leaves of corn, usually on the upper surface, where they are often located in the groove formed by the midrib, and are tightly fastened to the leaf.

THE PUPAL STAGE

As the length of time spent in the cocoon is comparatively short, it is probable that the larva pupates soon after finishing the cocoon. In Table 15 are presented the results of several observations of the interval between the spinning of the cocoon and the emergence of the adult. These intervals probably represent approximately the length of the pupal stage. The shortest interval was 5 days, in June, at a mean temperature of 81° F. In October, at 70°, the average interval for 24 males was 7 days. In one instance, in January, it was 14 days at a mean temperature of 64°.

TABLE 15.—*Interval of time from the spinning of the cocoon to the emergence of the adult of Apanteles marginiventris, at Brownsville, Tex., in the years 1913 to 1916, inclusive*

Date cocoons were spun	Date adults emerged	Adults		Interval	Mean temperature
		Number	Sex		
1913	1913			*Days*	°*F.*
Apr. 16	Apr. 24	1		8	74
Apr. 17	do	1		7	74
Nov. 13	Nov. 19	1		6	75
1914	1914				
June 10	June 13–15	28	Male	5	81
Oct. 24	Oct. 30	2	do	6	70
Do	Oct. 31	5	do	7	70
Do	Nov. 1	1	do	8	70
Oct. 25	Oct. 30	1	do	5	69
Do	Oct. 31	12	do	6	69
Do	Nov. 1	3	do	7	70
Do	Nov. 2	2	do	8	70
Oct. 26	Nov. 1	3	do	6	70
Do	Nov. 2	5	do	7	70
Do	Nov. 3	2	Female	8	70
Do	do	1	Male	8	70
Do	Nov. 4	1	do	9	70
Do	Nov. 5	2	Female and male	10	70
Oct. 27	Nov. 2	8	Male	6	70
Do	Nov. 3	1	do	7	70
1915	1915				
Nov. 16	Nov. 21	4	Undetermined	5	76
1916	1916				
Jan. 10	Jan. 24	1	Undetermined	14	64

SUMMARY OF DEVELOPMENTAL PERIOD

Apanteles marginiventris is a solitary endoparasite which oviposits in caterpillars of the first instar. The larva of the parasite emerges from the caterpillars of the fourth instar in from 7 to 14 days, and spins a small white cocoon on the plant, from which the adult emerges in from 5 to 14 days.

PARTHENOGENESIS

In June, 1914, one female, which had been reared from an isolated cocoon and had not been caged with males, was placed in a vial with caterpillars of the first instar. From this experiment 22 adults, all males, were reared. The experiment shows that this species may reproduce parthenogenetically and that the progeny of unfertilized females will be males. These parasites were not observed to copulate in the vials in which they were kept, and this may explain why nearly all of the adults reared in the life-history experiments recorded in Table 15 were males.

SEASONAL HISTORY

This species was reared from Laphygma caterpillars collected in the vicinity of Brownsville (Table 7) in the months of January, April, May, September, October, November, and December. There is no explanation for its absence from the collections of Laphygma made in June, July, and August, as rather a large number of caterpillars were collected in these three months. It was most numerous as a parasite of Laphygma in April, when about 7 per cent of all small caterpillars collected were found to be infested.

Apanteles marginiventris was reared from one host or another in every month except February, July, and August, and is probably active throughout the year at Brownsville.

The shortest time required for the complete development from oviposition to the emergence of the adult, according to the experiments at Brownsville, was 10½ days, in June. In October and November the time ranged from 13 to 19 days. There are no complete records for the winter months, but a record for November (Table 14) gives the period from oviposition to the spinning of the cocoon as 13 days, and a record for January (Table 15) gives the period from the spinning of the cocoon to the emergence of the adult as 14 days. We might assume, therefore, that the complete development during the winter months would require about 27 days.

OTHER HOSTS OF APANTELES MARGINIVENTRIS

This parasite was reared from *Laphygma exigua* Hbn., *Plathypena scabra* Fab., *Cirphis unipuncta* (Haw.), one or more species of Prodenia (see footnote 30, p. 56), a species of Autographa, and *Heliothis obsoleta* Fab., all collected in the vicinity of Brownsville.

PARASITES AND PREDACIOUS ENEMIES

In June, 1914, 14 cocoons of *A. marginiventris* were collected from corn, and from them were reared two specimens of a species of Hemiteles.

The cocoons of Apanteles are opened, and the larvae or pupae are eaten by lady beetles, in the same manner as *Sagaritis dubitatus* and *Meteorus laphygmae* are destroyed. In the field cocoons were observed which appeared to have been opened by predacious insects, and C. L. Scott observed an adult *Ceratomegilla fuscilabris* (Muls.) eating the pupa of Apanteles after it had opened the cocoon.

METEORUS LAPHYGMAE VIERECK [13]

Next to *Chelonus texanus*, the most important hymenopterous parasite of *Laphygma frugiperda* in the lower Rio Grande Valley is *Meteorus laphygmae*. Of about 9,000 small caterpillars collected (Table 7), 270, or about 3 per cent, were infested with this species. It appeared to be very numerous as a parasite of Laphygma on Bermuda grass during July, 1912, and about 40 per cent of the Laphygma caterpillars collected from barley in April, 1914, were infested with this species. Generally it appeared to be more numerous on such plants as barley, oats, or Bermuda grass than it was on corn.

DISTRIBUTION

From 3,424 larvae of Laphygma collected (Table 10) by members of the staff of the Brownsville field station at points in Texas outside the Rio Grande Valley, and at points in Oklahoma, Kansas, Arkansas, and Louisiana, only 8 Meteorus were reared, all from larvae collected from alfalfa at Shreveport, La., September 18, 1912.

THE ADULT

Laboratory experiments indicate that the adults of this species are long-lived. In one experiment, females which emerged from cocoons

[13] A solitary endoparasite, Hymenoptera, Braconidae.

on September 23 were kept in vials and fed on sugar sirup. Seven of them lived until October 27, or 34 days, and one lived until November 5, or 43 days. They were kept in the office, where the temperature was above 70° F. the greater part of the time.

It is not difficult to get these parasites to mate in the large vials, 28 millimeters wide by 100 millimeters long, in which it has been found convenient to keep them. The male pursues the female persistently, approaching from the rear with wings and antennae outspread and wings vibrating. The female holds her wings in the normal position. The male raises his head and brings it down, tapping the female sharply on the wings. This action may be repeated several times, but usually the courtship does not last long. Copulation lasts about two minutes.

Females of *Meteorus laphygmae* oviposit in caterpillars of the first or second instar. In laboratory experiments they would not oviposit in larvae of the third instar.

THE LARVAL STAGE

Details of life history, such as the length of the incubation period and the descriptions of the larval instars, were not worked out.

Numerous experiments were conducted to ascertain the length of time from oviposition to the spinning of the cocoon, and are summarized in Table 16. In some of these experiments Laphygmae larvae in the first instar were used; in others, larvae of the second instar. In June, at a mean temperature of 83° F., the interval from oviposition to the spinning of the cocoon was about two days longer when the eggs were deposited in caterpillars of the first instar than when the caterpillars were of the second instar; but at a mean temperature of 70° the interval seemed to be the same whether caterpillars of the first or of the second instar were used.

TABLE 16.—*Interval of time from oviposition to the spinning of the cocoon of Meteorus laphygmae, at Brownsville, Tex., from October, 1913, to November, 1914*

Date of oviposition	Date cocoons were spun	Number of cocoons	Interval	Mean temperature	Date of oviposition	Date cocoons were spun	Number of cocoons	Interval	Mean temperature
1913	1913		*Days*	*° F.*	1914	1914		*Days*	*° F.*
Oct. 18	Oct. 29	2	11	70	May 14	May 24	20	10	78
Do	Oct. 30	14	12	70	May 19	May 28	6	9	79
Do	Oct. 31	25	13	70	Do	May 29	13	10	79
Do	Nov. 1	5	14	70	June 21	June 28	7	7	83
Oct. 19	Oct. 31	23	12	69	Do	June 29	9	8	83
Do	Nov. 1	25	13	69	Sept. 24	Oct. 6	11	12	75
Oct. 22	Nov. 3	3	12	70	Sept. 30	Oct. 10	25	10	78
Do	Nov. 4	12	13	70	Oct. 1	Oct. 11	10	10	78
Do	Nov. 5	4	14	70	Oct. 16	Oct. 27	4	11	73
					Oct. 23	Nov. 4	14	12	71
1914	1914								
May 7	May 18	1	11	78					

The egg and larval stages together lasted about 10 days in May and September, at a mean temperature of 78° F., 7½ days in June, at a mean temperature of 83°, and about 12½ days in October, at a mean temperature of 70°.

Larvae of Meteorus emerge from the host caterpillar without killing it, but the caterpillar dies within a few days. In one experiment started with second-instar caterpillars the parasites emerged from 6

caterpillars which had heads 1.5 millimeters wide, and from 1 which had a head 1.3 millimeters wide. The heads of 25 caterpillars from which Meteorus larvae emerged on October 10 were 1.4 millimeters wide. These caterpillars were probably in the fifth instar, although they were smaller than normal caterpillars of that stage.

THE COCOON

The cocoon of *Meteorus laphygmae* is firm, brown, glassy, spindle-shaped, about 2 millimeters in diameter and 4½ to 5 millimeters in length. It is attached to the host plant of the caterpillar or to nearby objects by a thread of silk from one-half inch to 2 inches long. The adult parasite emerges by forcing off the cap, which usually remains attached at one side of the cocoon. In shape the cap is a truncated cone about two-thirds of a millimeter in height.

In spinning its cocoon the larva of Meteorus first builds a framework with a single thick thread of silk, formed by drawing the two threads which issue from the spinnerets across the side of the head so that they unite to form one thread. The larva fastens the thread securely to some object and then spins a few irregular loops to form the short thread at the end of which the cocoon is constructed, after which the framework is built by moving the head clockwise and spinning arches or open loops. The larva works toward the cap of the cocoon, and each loop is fastened at both ends to the loop behind. Sometimes the thread is fastened at several places to give strength. An opening is left at the cap end.

After the framework is finished the larva lines it by spinning back and forth in the direction of the longest diameter of the cocoon. Two parallel threads, one from each spinneret, are spun in this work. The double threads, which sometimes unite to form a single flat thread, cross and recross each other at an acute angle, forming a glassy sheet of silk. Each time the larva approaches the cap end of the cocoon it loops the thread along the edge of the opening, repeating this in narrowing loops until the thread follows the circumference of the opening.

As the cocoon is lined, the conical cap is formed by making this opening gradually smaller, the larva spinning around the circumference of the opening. This is not done at one time, but, while lining the cocoon, whenever the larva approaches the opening it draws the thread for a short distance along the circumference, thus gradually narrowing the opening, and finally closing it by spinning threads crisscross.

THE PUPAL STAGE

The cocoons of *Meteorus laphygmae* are transparent; it is therefore possible to observe the pupation of the larva and the development of the pupa. Pupation occurs soon after the cocoon is formed, and most of the time in the cocoon is spent in the pupal stage, but the exact length of that stage was not ascertained in the experiments at Brownsville. The head of the pupa and adult is always toward the small, or cap, end of the cocoon.

Numerous experiments were conducted to ascertain the length of time spent in the cocoon; these are summarized in Table 17. Females emerged 10 days after pupation and males 8.4 days after pupation, in November, when the mean temperature was 71° F. during the pupal period. Females emerged after 6 days, in October,

and males after about 7 days at a mean temperature of 75°. Males emerged after 5 days in June and July at mean temperatures of 80° and 83°, respectively. One female emerged in January, after spending about 18 days in the pupal stage.

TABLE 17.—*Interval of time from the spinning of the cocoon to the emergence of the adult of Meteorus laphygmae, at Brownsville, Tex., from January, 1913, to November, 1914*

Date cocoons were spun	Date adults emerged	Adults		Interval	Mean temperature
		Number	Sex		
1913	1913			*Days*	*° F*
Jan. 9–11	Jan. 28	1	Female	17–19	
1914	1914				
May 18	May 25	1		7	78
May 24	May 30	10	Male	6	80
May 28	June 2	6	do	5	80
June 28	July 3	7	do	5	83
Oct. 10	Oct. 16	2	do	6	75
Do	do	2	Female	6	75
Do	Oct. 17	1	Male	7	75
Do	Oct. 18	1	do	8	75
Oct. 11	do	2	do	7	74
Oct. 27	Nov. 4	2	do	8	71
Do	Nov. 5	1	do	9	71
Do	do	1	Female	9	71
Nov. 4	Nov. 12	2	Male	8	71
Do	Nov. 13	2	do	9	71
Do	Nov. 14	10	Female	10	71

SUMMARY OF DEVELOPMENTAL PERIOD

The eggs are deposited in first-instar or second-instar caterpillars. The parasitic larva develops inside the host, emerges from caterpillars of the fifth instar, spins a cocoon on the plant or other near-by object, and pupates. The adult parasite emerges in a comparatively short time, before the uninfested caterpillars complete their transformation and emerge as adults.

The entire life history, from oviposition to the emergence of the adult, was found to occupy a minimum of about 12 days in the summer, at a mean temperature of 83° F.; from 17 to 19 days in the fall, at 75°, and from 22 to 24 days at 70°; and 31 days or more in the winter.

PARTHENOGENESIS

One female of *Meteorus laphygmae*, which emerged from an isolated cocoon and had not been confined with males, was placed in a battery jar with second-instar and third-instar caterpillars on October 15, 1913. After two days 100 caterpillars were removed and isolated in tin boxes. Thirty cocoons were obtained, and 30 adults emerged, all of which were males.

NUMBER OF PROGENY FROM ONE FEMALE

The following experiment was carried on at Brownsville: A female *Meteorus laphygmae* was placed with first-instar caterpillars November 3, and with new first-instar caterpillars every day until November 12, when she died. Eighty-three cocoons were spun by the parasitic larvae which emerged from the infested caterpillars.

SEASONAL HISTORY

Meteorus laphygmae was reared at Brownsville from Laphygma caterpillars (Tables 7 and 8) collected in every month except February, March, and August; but it was also reared from larvae of *Cirphis unipuncta* (Haw.) and of *Cirphis latiuscula* (H. S.) collected in February and in March; it is therefore evident that this species is active throughout the year at Brownsville. Since the total length of the life cycle ranges from about 12 days in summer to about 31 days in winter, this species can complete many, probably about 18, generations during the year.

OTHER HOSTS OF METEORUS LAPHYGMAE

This parasite has been reared from caterpillars, collected at Brownsville, of *Feltia annexa* Treit., *Macaria punctolineata* Packard, a species of Autographa, one or more species of Prodenia (see footnote 30, p. 56), *Laphygma exigua* Hbn., *Eurymus eurytheme* Bdv., *Monodes nucicolora* Gn., *Cirphis latiuscula* (H. S.), *Cirphis unipuncta* (Haw.), and *Heliothis obsoleta* (Fab.)

PARASITES REARED FROM COCOONS OF METEORUS LAPHYGMAE

Many cocoons of *Meteorus laphygmae* have been collected at Brownsville for the purpose of rearing parasites. In July, 1912, E. G. Smyth first collected them from grasses and other objects near the insectary. Adults of the species had parasitized *Laphygma frugiperda*, at that time numerous as an army worm feeding on Bermuda and other grasses. In the interval from July 19 to 27, inclusive, 295 cocoons of *Meteorus laphygmae* were collected from Bermuda grass, weeds, and other objects. Nothing emerged from 64 of the cocoons; Meteorus and its parasites emerged from 231, these emergences being shown in Table 18. In one instance two parasites, a female *Dibrachys meteori* and a male *Spilochalcis delira*, issued from a single cocoon. In all, 180 parasites and 52 Meteorus issued from 231 cocoons. Seventy-eight per cent of the live cocoons were parasitized by parasites of seven different species.

TABLE 18.—*Parasites reared from cocoons of Meteorus laphygmae Viereck, collected and reared at Brownsville, Tex., by E. G. Smyth in July, 1912*

Date	Cocoons	Parasites								Meteorus adult emerging
		Spilochalcis pallens Cresson	Spilochalcis torvina Cresson	Dibrachys meteori Gahan	Hemiteles sp.	Myrmicomorpha perniciosa Viereck	Eupelminus meteori Gahan	Mesochorus sp.	Total	
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
July 19	11									11
July 22	31		9		2				11	20
July 23	38	17	5		3	1			26	12
July 24	52	19	2	11	7	5	3	1	48	4
July 25	83	33	15	11	7	5	5	2	78	5
July 27	16		7	7	3				17	
Total	231	69	38	29	22	11	8	3	180	52
Per cent		29.9	16.4	12.5	9.5	4.8	3.5	1.3	77.9	22.5

In 1914 many cocoons were collected from corn, and the parasites reared at the laboratory by the writer. From May 28 to June 19, 206 cocoons of *Meteorus laphygmae* were collected, from which were reared 1 larva of *Spilochalcis pallens* Cresson, 6 larvae of *Dibrachys meteori* Gahan, 11 of a species of Hemiteles, and 1 of a species of Eupelmus. From September 16 to 23, 568 cocoons were collected, from which were reared 4 larvae of *Spilochalcis pallens* Cresson and 3 of *Spilochalcis torvina* Cresson. Of the entire 774 cocoons only 26, or 3.3 per cent, were parasitized, whereas 78 per cent were parasitized in the collections from Bermuda grass. The reason for this is not evident. It may be because both the parasites and Meteorus were less numerous in 1914, but probably because the natural habitat of *Meteorus laphygmae* and its parasites is grassland or low-growing plants.

The parasites of Meteorus emerge through a hole which they cut in the side of the cocoon.

PREDACIOUS ENEMIES

The writer has observed an adult lady beetle, a species of Megilla, gnawing at a cocoon of *Meteorus laphygmae* on a corn leaf, with the evident intention of opening it. Cocoons of Meteorus which had apparently been opened by lady beetles were sometimes observed, but not so frequently as the cocoons of several other species. C. L. Scott made the following field note on June 11, 1914, at Brownsville:

> In collecting cocoons of parasitic Hymenoptera for the last several days I note that the cocoon of Meteorus is rarely attacked by lady beetles, presumably on account of its being suspended loosely by a silken thread, which would make it difficult to gnaw through, and on account of the preference shown for *Sagaritis dubitatus*.

ROGAS LAPHYGMAE VIERECK[14]

Of about 9,000 small caterpillars of *Laphygma frugiperda* (Table 7) collected in the vicinity of Brownsville, only 44 Rogas were reared, or one-half of 1 per cent of all of the small larvae collected. This parasite was reared from caterpillars collected in April, May, and June. It was most numerous in May, when it infested a little more than 2 per cent of all the small caterpillars collected in that month.

This parasite was reared from caterpillars collected at Shreveport, La., but not from any of the other localities (Table 10) where collections were made outside of the Rio Grande Valley.

Rogas laphygmae usually oviposits in caterpillars which are well toward the end of the first instar. The female usually has to wrestle with the caterpillar, as she does not seem to be able to oviposit quickly and get away.

THE LARVAL STAGE

The number of days from oviposition to the spinning of the cocoon (Table 19) ranges from five to nine, which probably represents approximately the length of the larval stage, as the egg stage must be short in order to allow time for the development of the larva.

---

[14] A solitary endoparasite, Hymenoptera, Braconidae.

TABLE 19.—*Interval of time from oviposition to the spinning of the cocoon of Rogas laphygmae Viereck at Brownsville, Tex., in 1914*

Date of oviposition	Date cocoons were spun	Number of cocoons	Interval	Mean temperature	Date of oviposition	Date cocoons were spun	Number of cocoons	Interval	Mean temperature
			Days	*° F.*				*Days*	*° F.*
May 19	May 27	9	8	79	June 19	June 25	4	6	83
May 20	May 29	1	9	79	Do	June 26	3	7	83
June 7	June 14	7	7	81	June 22	June 27	10	5	83
June 14	June 21	3	7	83					

The heads of four Laphygma larvae within which cocoons were spun measured from 0.9 to 1 millimeter. These larvae were of the general size of uninfested caterpillars of the third instar, but as their heads were too wide for that stage they must have been in the fourth instar. Their heads, however, were narrower than those of normal caterpillars of the fourth instar. Uninfested caterpillars develop to the fifth instar in the same length of time.

THE COCOON

The Rogas larva does not emerge from its host, but spins its cocoon within the dried skin of the caterpillar. When the parasitic larva is mature it fills the body of the caterpillar, which dies and remains attached to the plant by its prolegs. The parasite cleans out the head and thorax of the caterpillar, and then works on the ventral side of the thorax until only the epidermis is left. It soon breaks through this and pushes out of the body the fluids and material it does not eat. The drying of these fluids attaches the caterpillar to the plant. The skin of the caterpillar collapses over the thorax and over the anal pair of prolegs, and between these collapsed portions the larva spins its cocoon. As the body fluids of the caterpillar are taken up by the parasite or ooze out, the skin, which is kept expanded by the larva, dries and forms a strong protection for the cocoon.

The cocoon, so called, of Rogas, wherever it is discussed in this bulletin, includes the dried skin of the host caterpillar within which the real cocoon is spun. It is light brown, dry and firm, about 8 millimeters long, having the thorax and anal portion of the abdomen collapsed. Most of the abdominal somites are expanded, and the cocoon is spun within this expanded portion.

In the cornfield the cocoons are found on the leaves or the stalks of the corn plant, but may also be found on weeds or other objects, as the infested caterpillars often wander from the place where they were feeding. In July, 1912, E. G. Smyth found cocoons on the brick wall of the insectary, on stems of Bermuda grass, and on a palm leaf. The infested caterpillars had been feeding on Bermuda grass.

THE PUPAL STAGE

The adult parasite emerges through a round ragged hole cut through the dorsal side of the caterpillar near its anal end. The larvae probably pupate as soon as they finish their cocoons, and the time spent in the pupal stage (Table 20) is about five days, at a temperature of 82°.

TABLE 20.—*Interval of time from the spinning of the cocoon to the emergence of the adult of Rogas laphygmae at Brownsville, Tex., in 1914*

Date cocoons were spun	Date adults emerged	Adults		Interval	Mean temperature
		Number	Sex		
				Days	*° F.*
May 27	June 1	7	Male	5	79
May 29	June 3	1	?	5	79
June 14	June 19	1	Male	5	82
Do	do	2	Female	5	82
June 15	June 20	1	Male	5	82
Do	do	2	Female	5	82
June 21	June 25	2	do	4	83
June 25	June 30	3	do	5	83

SUMMARY OF DEVELOPMENTAL PERIOD

Rogas laphygmae is a solitary endoparasite which oviposits in caterpillars of the first instar. The infested caterpillar dies in the fourth instar, and the parasitic larva spins its cocoon within the dried skin of its host. The larval stage occupies from 5 to 9 days, and the pupal stage about 5 days. The entire developmental period is completed in from 11 to 14 days.

PARTHENOGENESIS

Several experiments were conducted with unfertilized females, which oviposited in the caterpillars in the normal manner. The adults reared from these experiments were all males.

SEASONAL HISTORY

As has been mentioned, this parasite was reared from caterpillars collected from corn in April, May, and June. As its life history is short, it could pass through about six generations during these three months, and it is difficult to account for the fact that it was not reared from caterpillars collected in other months in the year. It would be necessary, however, to collect in each month large numbers of the caterpillars in the second instar or early in the third to arrive at a definite conclusion, as in ordinary collecting a larger proportion of the larger caterpillars are selected. E. G. Smyth collected six cocoons from Bermuda grass between July 22 and July 25, 1912, and it is possible that Rogas may be found to be more numerous in some other habitat than in the cornfield. One cocoon was collected from corn on September 17, 1914. This parasite was reared only from *Laphygma frugiperda*.

PARASITES OF ROGAS LAPHYGMAE

On July 25, 1912, E. G. Smyth collected four cocoons of Rogas from Bermuda grass at Brownsville, from three of which he reared three species of parasites, *Myrmicomorpha perniciosa* Viereck, *Spilochalcis pallens* Cresson, and a species of Hemiteles. Two other cocoons collected in July were unparasitized; of the six cocoons, 50 per cent were parasitized. These collections were made during a local outbreak of the fall army worm on Bermuda grass.

From May 28 to June 19, 1914, 124 cocoons of *Rogas laphygmae* were collected from corn at Brownsville. Five individuals of a species of Hemiteles and six of *Dibrachys meteori* Gahan were reared from 11 of these cocoons, or 9 per cent of the number collected.

ZELE MELLEUS (CRESSON)[15]

The species *Zele melleus* appears to be a rare parasite of *Laphygma frugiperda*, as only three specimens were reared from about 16,000 caterpillars (Tables 7 and 8) collected in the vicinity of Brownsville. These were reared in October in 1913 and in 1914. It was not reared from any other host.

One specimen was reared (Table 10) from caterpillars collected at Shreveport, La., in 1912.

Nothing was learned concerning the life history or habits of this species.

SAGARITIS DUBITATUS (CRESSON)[16]

The parasite *Sagaritis dubitatus* was reared from caterpillars of *Laphygma frugiperda* collected (Table 7) in the vicinity of Brownsville in January, April, May, June, and July. It was reared from larvae of *Heliothis obsoleta* collected in March. It was most numerous in April and May, infesting about 10.5 per cent of all of the small caterpillars collected in those two months. Of more than 9,000 small larvae collected (Table 7) only about 3 per cent were infested by Sagaritis.

One specimen of *S. dubitatus* was reared at Brownsville from a collection of Laphygma caterpillars made by C. L. Scott at Wellington, Kans., August 14, 1915. It was not reared from any of the other collections (Table 10) from localities outside of the Rio Grande Valley.

Females of this parasite confined in vials would not oviposit in Laphygma larvae which had just hatched, but oviposited in caterpillars that were about at the end of the first instar or in the second instar. The female first examines a caterpillar by waving her antennae over it, and then, bending her abdomen under her, she thrusts it forward and inserts her ovipositor. The entire performance requires only a couple of seconds.

THE LARVAL STAGE

The interval of time from oviposition to the emergence of the larva of the parasite from the host is short, and probably most of this time is spent in the larval stages. As set forth in Table 21, the number of days ranged from 7 to 10, with an average of 8 in May and June, at a mean temperature of 78° or 79° F.

This parasite almost entirely destroys the infested caterpillars, which succumb in the fourth instar. Infested caterpillars containing nearly full-grown parasites stretch out and become rigid. Because of the color of the parasitic larva, which may be seen through the thin skin, the host larva appears white. At this time the parasite soon eats out the entire contents of the caterpillar, leaving only the skin, which is filled by the parasite. The infested caterpillar remains attached to the plant by its prolegs.

The parasitic larva, with its head toward the anal end of the caterpillar, breaks out on the ventral side, in front of the prolegs, partially crawls out, turns forward, or toward the head of the caterpillar, and swings back its anal end in such a way that the skin of the caterpillar is folded back upon itself. The parasite then crawls forward and out of the empty skin, which is partly drawn with it and remains stretched out on the plant.

---

[15] A solitary endoparasite, order Hymenoptera, family Braconidae.
[16] A solitary endoparasite, Hymenoptera, Ichneumonidae, Ophioninae, Camploplegini.

TABLE 21.—*Interval of time from oviposition to the spinning of the cocoon of Sagaritis dubitatus at Brownsville, Tex., in 1913 and 1914*

Date of oviposition	Date cocoons were spun	Number of cocoons	Interval	Mean temperature	Date of oviposition	Date cocoons were spun	Number of cocoons	Interval	Mean temperature
1913	1913		*Days*	° *F.*	1914	1914		*Days*	° *F.*
June 9	June 16	41	7	79	May 16	May 25	9	9	78
Do	June 17	36	8	79	Do	May 26	3	10	78
					May 20	May 28	10	8	79
1914	1914								
May 16	May 24	13	8	78					

THE COCOON

Some larvae begin to spin their cocoons as soon as they emerge halfway from the skin of the caterpillar; others entirely emerge and crawl a few millimeters before beginning to spin.

The larva starts the framework of the cocoon by attaching threads to the plant on one side of itself and then to its own dorsum, repeating this process on the other side by attaching threads to the plant and then to those already spun, where they are attached to its dorsum, thus forming a belt over itself. This belt becomes the anal end of the cocoon. The larva, with its ventral side uppermost, then works forward in the construction of the cocoon. It reaches forward to one side and attaches a thread to the plant, then brings its head back, spinning a thread which it attaches several times to the belt already formed, making open loops, and brings the end of the thread forward and attaches it to the plant on the other side. The larva repeats this process, attaching the new loops to those already formed, until it reaches the place that is to be the cephalic end of the cocoon; it then attaches the ends of several threads to the plant at one place on each side. It next fills in this end of the cocoon by spinning threads back and forth across it. The larva then completes the framework by spinning threads forward and backward across the loops, reversing its position so that it can get at all parts of the cocoon. The framework is made of single thick threads, probably formed by the union of two threads, one from each spinneret, and its construction occupies about 45 minutes.

After the framework is finished, the larva lines it by spinning two parallel threads at the same time; these run in every direction and cross and recross each other until the cocoon is lined by a continuous layer of silk. In about two hours the larva completes the work to a point where further observation is impossible.

The cocoon of *Sagaritis dubitatus* is cylindrical, with rounded ends. It is opaque, and gray or brown in color, sometimes with areas of black.

These cocoons were often found on corn plants at Brownsville in April, May, and June. They were usually found on the upper side of the leaf, frequently in the groove formed by the midrib.

THE PUPAL STAGE

As the length of time in the cocoon is short (Table 22), it is probable that the larva pupates soon after the cocoon is finished. On this basis the length of the pupal stage is five or six days in May or June, at a mean temperature of 80° F., and seven or eight days in April, at a mean temperature of 74°.

TABLE 22.—*Interval of time from the spinning of the cocoon to the emergence of the adult of Sagaritis dubitatus at Brownsville, Tex., in 1913 and 1914*[1]

Date cocoons were spun	Date adults emerged	Adults		Interval	Mean temperature
		Number	Sex		
1913	1913			*Days*	° *F.*
Apr. 16	Apr. 24	5	?	8	74
Apr. 17	do	2	?	7	74
June 7	June 13	1	?	6	79
June 15-16	June 21-22	1	Male	6	80
June 16	do	12	do	5½	80
Do	June 22	12	do	6	80
June 16-17	June 21-22	1	do	5	80
Do	June 22	12	do	5½	80
Do	June 22-23	11	do	6	80
1914	1914				
May 24	May 29	10	Male	5	80
May 28	June 2	10	do	5	80

[1] All experiments in June, 1913, were performed by O. W. Rosewall, who made observations twice each day, the double dates (e. g., June 15-16) indicating that the event recorded occurred at night. The single dates in Mr. Rosewall's experiments show that the event recorded occurred between 8 a. m. and 5 p. m. The experiments in April, 1913, and May, 1914, were performed by the writer, who made observations once a day.

SUMMARY OF DEVELOPMENTAL PERIOD

Sagaritis dubitatus is a solitary endoparasite which oviposits in Laphygma caterpillars of the first and second instars. The host caterpillar is destroyed in the fourth instar, and the cocoon is spun on the plant.

The entire time from oviposition to the emergence of the adult occupies from 12 to 16 days in May or June, at a mean temperature of 80° F., and possibly as long as 17 or 18 days in April, at a mean temperature of 74°.

SEASONAL HISTORY

As has been mentioned in the first paragraph under *Sagaritis dubitatus*, this species was reared at Brownsville from collections made in the months from January to July, with the exception of February. It was entirely absent from the collections made during the last six months of the year, or from August to December, and no information was obtained that would explain this seasonal distribution. As the entire life history requires only from 12 to 18 days, it can pass through 8 to 10 generations during the period from January to July, and experiments at Brownsville indicate that it goes through one short generation after another. The activity of this species throughout the year would therefore be expected. Probably it should be looked for in other hosts during the fall and winter.

OTHER HOSTS OF SAGARITIS DUBITATUS

Sagaritis dubitatus was also reared at Brownsville from *Laphygma exigua* Hbn., *Heliothis obsoleta* (Fab.), a species of Autographa, and one or more species of Prodenia (see footnote 30, p. 56).

PARASITES AND PREDACIOUS ENEMIES

In June, 1914, 332 cocoons of *S. dubitatus* were collected from corn at Brownsville, of which 12, or 3.6 per cent, were found to be parasitized. From the 12 parasitized cocoons were reared 9 individuals of *Dibrachys meteori* Gahan, 2 of a species of Hemiteles, and 1 of a species of Eupteromalus.

The cocoons of this species are frequently attacked and opened by lady beetles. The writer observed adults of *Ceratomegilla fuscilabris* attacking these cocoons, and C. L. Scott observed the adults of this lady beetle opening cocoons of Sagaritis and eating the pupae. He counted 90 cocoons, of which 30 had been opened, presumably by lady beetles.

NEOPRISTOMERUS APPALACHIANUS VIERECK[17]

Neopristomerus appalachianus was reared from caterpillars of *Laphygma frugiperda* collected in the vicinity of Brownsville in every month in the year (Table 7) except December, January, and February, and was most numerous in April, May, June, and July, when it infested 1.4 per cent of all of the small caterpillars collected. Larger collections of young caterpillars during the winter months might show that this species is active throughout the year at Brownsville. It was reared from *Laphygma exigua* Hbn. in October, and from one or more species of Prodenia in April and July (see footnote 30, p. 56).

Neopristomerus appalachianus was reared at Brownsville from Laphygma caterpillars collected (Table 10), by members of the staff of the Brownsville field laboratory, at Victoria, College Station, Whittaker, Kyle, Waco, and Dallas, Tex.; at Sulphur Springs, Okla., and at Shreveport, La.

Very little was learned concerning the habits and life history of this parasite. Experiments in breeding it were unsuccessful, owing to failure to get the females to oviposit. One female, which was kept in a small vial in a heated room and fed on sugar sirup, lived 39 days. One larva spun a cocoon on April 5, 1916, and the adult emerged on April 17. The length of time in the cocoon was 12 days, at an average temperature of 74° F.

OPHION BILINEATUS SAY[18]

Ophion bilineatus appears to be very effective at times, and in some localities, but usually it is not very numerous. Of 7,121 large caterpillars of Laphygma collected in the vicinity of Brownsville (Table 8), 120, or about 1.7 per cent, were infested with Ophion. It was reared from caterpillars collected in the vicinity of Brownsville in every month of the year except February, March, and July, but was most numerous in October. Of 550 large caterpillars of Laphygma collected from one field in October, 1913, 11 per cent were infested with this species.

DISTRIBUTION

This parasite was reared from caterpillars of *Laphygma frugiperda* collected (Table 10), by members of the staff of the Brownsville field laboratory, from the following localities in Texas: Odem, Beeville, Victoria, Yoakum, Brazoria, Wharton, Sugarland, and Whittaker. In some of these localities it was more numerous than at Brownsville, as it destroyed 16 per cent of the total number of caterpillars collected at Beeville, Brazoria, Sugarland, and Victoria. Of 134 caterpillars collected at Sugarland, 84, or more than 62 per cent, were infested with this species.

---

[17] A solitary endoparasite, Hymenoptera, Ichneumonidae, Ophioninae, Cremastini.
[18] A solitary endoparasite, Hymenoptera, Ichneumonidae, Ophioninae, Ophionini.

OVIPOSITION

In the experiments with this parasite in the laboratory at Brownsville, 6-inch battery jars and 9-inch aquarium jars were used for cages, as were also large glass-covered trays 2 feet square by 4 inches deep. The parasites were not observed to copulate in these cages, and it is probable that large flight cages should be used in breeding them.

The females oviposited in the daytime in caterpillars of the second, third, and fourth instars, and the parasitic larvae emerged later. Caterpillars of the third or fourth instar appear to be in the most favorable stage.

In oviposition the female rises on her legs, brings the tip of her abdomen under herself, and thrusts it forward, stabbing the caterpillar quickly and without caution. She withdraws her ovipositor immediately.

THE LARVAL STAGE

The number of days from oviposition to the emergence of the parasitic larva from the host is short, being in experiments at Brownsville about 10 days (Table 23), so the eggs must hatch soon after oviposition.

The Ophion larvae usually emerge from full-grown caterpillars. Sometimes, though rarely, they emerge from the pupae. The full-grown parasitic larva eats out all of the body tissues and fluids of the host, leaving only the skin, which is completely filled by the parasite just before it emerges.

TABLE 23.—*Interval of time from oviposition to the spinning of the cocoon of Ophion bilineatus at Brownsville, Tex., in 1913 and 1914*

Date of oviposition	Date cocoons were spun	Number of cocoons	Interval	Temperature
1913	1913		*Days*	° *F.*
Nov. 13	Nov. 24	1	11	76
1914	1914			
Oct. 10	Oct. 19	4	9	75
Do	Oct. 21	7	11	75
Oct. 12	do	1	9	74

THE COCOON

Under natural conditions the parasite would emerge from the host after the caterpillar had entered the soil and had prepared a cell for pupation. The parasite would then spin its cocoon within this cell. It spins the cocoon soon after emergence from the host, usually completing it the following day.

In the experiments at Brownsville Laphygma caterpillars infested with this parasite were isolated in 1-ounce tin boxes to prevent them from eating one another. The Ophion larvae had difficulty in building cocoons in these boxes, and always failed to complete the cocoons unless leaves or other material were so placed as to give support on all sides. In other words, these larvae line a cavity with silk to form a cocoon, instead of constructing the cocoon around themselves, as do Meteorus and Sagaritis. Those larvae died which failed to complete their cocoons.

THE PUPAL STAGE

The time spent in the cocoon varies considerably. In May and June, at a mean temperature of 82° F., it ranged (Table 24) from 13 to 18 days, with an average of 14½ days, for males; and from 14 to

20 days, with an average of 16 days, for females. In October and November (Table 25) the time was longer, being 20 days at a mean temperature of 73°, and 30 days at 67°. In these cases, especially those of the shorter periods of 14 to 16 days, the larvae probably pupated soon after completing the cocoon; and the interval named probably represents the length of the pupal stage, which would vary as influenced by the temperature.

Very often the parasites failed to emerge from these cocoons at the normal time, and when such cocoons were examined, after being kept in the laboratory for several months, they were found to contain larvae. Usually the adults were not successfully reared from these cocoons, but in one instance (Table 25) the adult emerged after 103 days. The length of the pupal stage in such cases is probably of normal duration, the most of the time in the cocoon being spent in the larval stage.

TABLE 24.—*Interval from the spinning of the cocoon to the emergence of the adult of Ophion bilineatus at Brownsville, Tex., in May and June, 1915*

Date cocoons were spun [1]	Date adults emerged	Adults		Interval	Mean temperature
		Male	Female		
				Days	° *F.*
May 17	May 31	1		14	82
	June 1	2	1	15	82
	June 2		1	16	81
	June 3		1	17	81
May 18	May 31	3		13	82
	June 1	6	2	14	82
	June 2	3	4	15	82
	June 3		4	16	82
	June 4		2	17	82
	June 7		1	20	82
May 19	June 1	1		13	82
	June 2	4		14	82
	June 3	6	2	15	82
	June 4	3	3	16	82
May 20	June 2	1		13	82
	June 3	7		14	82
	June 4	5		15	82
	June 5		6	16	82
	June 7	1	2	18	82
May 21	June 4	2		14	82
	June 5	1	2	15	82
May 22	June 7	1	1	16	82
	June 10		1	19	82

[1] The caterpillars were collected at Sugarland and Brazoria, Tex., in May, 1915, and the parasites were reared at Brownsville.

TABLE 25.—*Interval of time from the spinning of the cocoon to the emergence of the adult of Ophion bilineatus at Brownsville, Tex., in 1913, 1914, and 1915*

Date cocoons were spun	Date adults emerged	Adults		Interval	Mean temperature
		Number	Sex		
1913	1913			*Days*	° *F.*
May 8	May 24	1	?	16	
Oct. 19	Nov. 14	1	?	26	69
Nov. 24	Dec. 24	1	Male	30	67
1914	1914				
Sept. 17	Oct. 9	1	Male	22	78
Oct. 19	Nov. 8	1	do	20	73
1915	1915				
May 30	Sept. 10	1	Male	103	

SUMMARY OF DEVELOPMENTAL PERIOD

The female *Ophion bilineatus* oviposits in caterpillars of the second, third, or fourth instar. The mature parasitic larva emerges after the caterpillar has entered the soil and formed a cell for pupation, or after about 10 days. It then spins its cocoon within this cell, from which the adult may emerge in about 15 days.

In a few experiments, recorded in Table 26, the interval elapsing from oviposition to the emergence of the adult ranged from 29 days to 41 days. In two of these experiments, begun in November, 1913, oviposition in second-instar larvae resulted in the longer time, 46 days, whereas the use of larvae of the third and fourth instars gave the shorter interval of 41 days. In the experiments at Brownsville the larval stage under otherwise identical conditions lasted from 3 to 5 days longer when the younger caterpillars were used, the development of the parasite appearing to correspond with the growth of the caterpillar.

NUMBER OF PROGENY FROM ONE FEMALE

One female Ophion was placed for five hours in a large glass-covered tray with third-instar and fourth-instar caterpillars on October 10, 1914; 20 Ophion larvae later emerged from 20 of the caterpillars.

TABLE 26.—*Interval of time from oviposition to the emergence of the adult Ophion bilineatus at Brownsville, Tex., in 1913 and 1914*

Date of oviposition	Date adults emerged	Number of adults[1]	Interval	Temperature	Date of oviposition	Date adults emerged	Number of adults[1]	Interval	Temperature
1913	1913		*Days*	° *F.*	1914	1914		*Days*	° *F.*
Nov. 7	Dec. 23	1	46	69	Oct. 10	Nov. 8	1	29	74
Nov. 13	Dec. 24	1	41	69	Do	Nov. 11	2	32	74

[1] All males.

SEASONAL HISTORY, OTHER HOSTS, AND ENEMIES

Caterpillars parasitized by Ophion do not seem to be retarded in growth. The parasites emerge from the host about the time that the uninfested caterpillars are pupating. They remain in the cocoon long enough to allow the adult Laphygma to emerge and lay eggs and for the eggs to hatch. In other words, the length of the generation in the parasite corresponds to the length of a generation in the host.

This parasite appears to be active throughout the year at Brownsville, and probably passes through about 11 generations.

Ophion bilineatus was also reared from *Laphygma exigua* Hbn.

No predacious enemies of Ophion were noticed, and no parasites were reared from it; but no cocoons were collected in the field for the purpose of rearing parasites. It therefore remains uncertain whether or not Ophion has parasites at Brownsville.

EUPLECTRUS PLATYHYPENAE HOWARD[19]

Euplectrus platyhypenae is a well-known parasite which attacks caterpillars of many species, usually attacking the later instars of its host. Of about 7,000 large caterpillars of Laphygma (Table 8) collected in the vicinity of Brownsville, 117, or about 1½ per cent, were parasitized by this species. It was most numerous in May, and

[19] A gregarious Ectoparasite, Hymenoptera, Eulophidae.

in this month it was reared from about 8 per cent of all of the large caterpillars collected.

E. platyhypenae was reared at Brownsville from caterpillars of *Laphygma frugiperda* (Table 10) collected, by members of the staff of the Brownsville field laboratory, at Beeville, Tex., and Morrilton and Texarkana, Ark.

THE ADULT

Adults emerged from cocoons September 18, 1914, and were placed in a large vial and fed on sugar sirup. They did well under these conditions and lived a long time, the last one dying on December 24, or at the end of 97 days. These parasites were kept in the office of the Brownsville field laboratory, where the temperature was above 70° F. most of the time.

THE INCUBATION PERIOD

The eggs are ovoid in shape and white when first laid, changing later to gray and finally to shining black. They are deposited on the surface of the caterpillar, usually in a group of from 20 to 30. When the eggs hatch they open lengthwise, and the young larvae immediately attach themselves to the caterpillar at the spot where the eggs were located.

The incubation period, as observed at Brownsville, lasted about 3 days in May or June (Table 27), at a mean temperature of 80° F., and 6 days in November, at a mean temperature of 68°.[20]

THE LARVAL STAGE

The larvae are pale green and pear-shaped, having the smaller, or cephalic, end attached to the caterpillar and the rest of the body free. They remain in a cluster, as the eggs were laid, and do not change their position until they are ready to pupate. The number of parasites to a single caterpillar of Laphygma ranged, according to the observations at Brownsville, from 1 to 45. The greatest number that may occur in one cluster is about 30, but there may be more than one cluster on a single host.

The length of the larval stage (Table 28) was observed to be about 3½ days in May, at a mean temperature of 80° F., and about 5 days in November, at a mean temperature of 72°.

TABLE 27.—*Incubation period of the eggs of Euplectrus platyhypenae at Brownsville, Tex., in 1913, 1914, and 1915*

Date of oviposition	Hour of oviposition	Date of hatching	Hour of hatching	Period	Mean temperature
1913		1913		*Days*	° *F.*
June 15	8 to 12 a. m.	June 18	8 to 12 a. m.	3	80
1914		1914			
May 5–6		May 8–9		3	80
May 7	11 a. m.	May 10		3	80
May 13	9 a. m.	May 16	6 p. m.	3¼	77
May 21–22		May 24–25		3	80
Oct. 28–29		Nov. 4	8 to 12 a. m.	6	68
1915		1915			
May 19–20		May 22–23		3	78
May 20–21		May 23	12 m.	2½	79
Do		May 23–24		3	79
May 21–22		May 24–25		3	80

[20] The observations embodied in Tables 27, 28, and 29 were usually made at 9 a. m. and 4 p. m.; if the event recorded occurred between 9 a. m. and 5 p. m., the date is recorded; if it occurred at any other time, the two possible dates are given, connected by a hyphen. Many of the observations were made by C. L. Scott, at the time an assistant at the Brownsville field laboratory.

TABLE 28.—*Duration of larval stage of Euplectrus platyhypenae as observed at Brownsville, Tex., in 1914*

Date eggs hatched	Hour eggs hatched	Date cocoons were spun	Hour cocoons were spun	Duration of stage	Mean temperature
				Days	° *F.*
Apr. 16	5 p. m.	Apr. 20	1 to 5 p. m.	4	74
May 8–9		May 11–12		3	80
May 10		May 13–14		3½	79
May 24–25		May 28		4	80
Nov. 4	8 to 12 a. m.	Nov. 9	8 to 12 a. m.	5	72
Nov. 12–13		Nov. 17	do	4½	74

THE PUPAL STAGE

When the Euplectrus larvae are mature they release their hold on the caterpillar, which collapses and remains flattened and stretched out its entire length on the host plant. The larvae crawl under the caterpillar and spin their cocoons side by side. The cocoons appear to be little more than cells formed between the caterpillar and the plant by partitions which are made of loosely woven thick threads of silk.

The length of the pupal stage (Table 29) was not more than 5 days in July, at a mean temperature of 83° F., about 6 days in May and June, at a mean temperature of 80°, and about 8 days in April, at a mean temperature of 75°.

TABLE 29.—*Interval of time from the spinning of the cocoon to the emergence of the adult of Euplectrus platyhypenae at Brownsville, Tex., in 1911, 1912, and 1914*

Date cocoons were spun	Date adults emerged	Interval	Mean temperature	Date cocoons were spun	Date adults emerged	Interval	Mean temperature
1911	1911	*Days*	° *F.*	1914	1914	*Days*	° *F.*
Apr. 24	May 1	7	80	Apr. 20	Apr. 27–29	8	75
				May 28	June 3	6	80
1912	1912			Nov. 17	Nov. 23	6	77
July 25	July 30	5	83				

SUMMARY OF DEVELOPMENTAL PERIOD

The eggs are deposited externally, or on the skin of the host, in a cluster; the larvae after hatching remain in a cluster, sucking the juices of the caterpillar and finally pupating under its extended dead body. The incubation period lasts from 3 to 6 days, the larval stage from 3½ to 5 days, and the pupal stage from 5 to 8 days. The length of the total life history ranges from about 11 days in the summer to 19 or more days in the winter.

PARTHENOGENESIS

An unfertilized female, used in one experiment, deposited eggs which hatched, and the resulting larvae developed into adults. The sex of these adults was not recorded in the notes.

SEASONAL HISTORY

At Brownsville this species was reared from Laphygma caterpillars (Tables 7 and 8) collected in every month of the year except February,

March, and August. However, it was reared from caterpillars of *Cirphis latiuscula* collected in March and from larvae of *Cirphis unipuncta* collected in February; it therefore appears to be active throughout the year.

The total life cycle requires about 11 days in the summer months, about 19 days in the fall and spring, and a longer period in December, January, and February. Euplectrus can pass through from 18 to 20 generations during the year.

OTHER HOSTS, PARASITES, AND PREDACIOUS ENEMIES

Adults of *Euplectrus platyhypenae* have been reared from host caterpillars of *Laphygma exigua* Hbn., *Cirphis latiuscula* H. S., *Cirphis unipuncta* (Haw.), and one or more species of Prodenia (see footnote 30, p. 56), all collected at Brownsville.

From June 1 to June 11, 1914, 60 caterpillars of Laphygma parasitized with cocoons of Euplectrus were collected at Brownsville from corn and kept for the purpose of rearing the parasites. Smaller numbers were collected in other months, but no parasites of Euplectrus were reared from these collections.

In 1912 two caterpillars of Laphygma parasitized with cocoons of Euplectrus were collected from corn by the writer at Tallulah, La., from which were reared the two species of parasites *Tetrastichus euplectri* Gahan and *Tetrastichus dolosus* Gahan.

Adults of the lady beetle *Ceratomegilla fuscilabris* have been observed at Brownsville feeding on pupae of *Euplectrus platyhypenae*.

FRONTINA ARCHIPPIVORA SCUDDER[21]

Only a few specimens of the tachinid parasite *Frontina archippivora* were reared from the collections made at Brownsville, and none from any other host than Laphygma. Of more than 16,000 caterpillars of *Laphygma frugiperda* collected (Tables 7 and 8) only 6 specimens of Frontina were reared; and as these collections were made during most of the months of the year and covering a period of several years, it appears that this species is a rare parasite of *L. frugiperda* in the cornfields at Brownsville. However, it might be more numerous in some other habitat or during an outbreak of the fall army worm.

Two specimens of this parasite were reared from larvae collected at Victoria, Tex. (Table 10), the only locality except Brownsville from which it was reared.

Specimens were reared from larvae of Laphygma collected at Brownsville in May, 1911, in April, June, and July, 1914, and in June, 1916.

Little was learned concerning the habits and life history of this species, except that the host is killed in the larval stage.

ARCHYTAS PILIVENTRIS VAN DER WULP[22]

Archytas piliventris is a common tachinid parasite of *Laphygma frugiperda* in southern Texas. Its natural habitat appears to be fields of tall-growing grasses, such as corn, the sorghums, and sugar cane. It was reared from 5.2 per cent of all caterpillars collected in the vicinity of Brownsville (Tables 7 and 8), and is next in importance

[21] Diptera, Tachinidae. [22] Diptera, Tachinidae.

to *Chelonus texanus* as a parasite of Laphygma in the cornfields. Apparently its attack is principally against caterpillars in the later stages, the fifth and sixth instars, of which 10.6 per cent (Table 8) are infested by this species. It may be considered a destroyer of at least 10 per cent of all the caterpillars of Laphygma that escape infestation by other parasites. If larger numbers of caterpillars in the sixth instar were collected and reared, they probably would show a greater percentage of infestation.

This parasite was reared from larvae of *L. frugiperda* collected (Table 10), by members of the staff of the Brownsville field laboratory, at Beeville, Victoria, and Sugarland, Tex. These localities are all in the Gulf coast district.

It was difficult to keep reared adults of *Archytas piliventris* alive in cages until they were ready to deposit their larvae. E. G. Smyth kept some of them in large lantern globes and observed them copulating in these cages, but did not succeed in keeping them alive long enough to observe their life history. The writer was able to keep them alive about 12 days in narrow upright screen cages 8 by 10 inches by one-half inch, and the life history was first worked out with flies kept in such cages; but it was found easier to use flies captured in the field.

Several experiments were conducted in October, 1914. In one, six Archytas females, which had been kept in a cage from 7 to 12 days, were placed in a large glass-covered tray with caterpillars of Laphygma in the fifth and sixth instars feeding on corn leaves. The act of larviposition and the habits of the young maggots were observed in this experiment, as described in the three paragraphs which follow. After a few hours the caterpillars were removed and isolated in tin boxes, and the adults were reared from them. The experiment was repeated several times with reared flies, and with one fly brought from the field.

LARVIPOSITION

Archytas piliventris deposits live larvae on the host plant of the caterpillar, as was observed by the writer during the progress of several experiments in the laboratory. A female Archytas would approach a caterpillar on a corn leaf and quickly deposit several larvae near it on the leaf. One fly, which was caged with caterpillars feeding on corn leaves, deposited 15 maggots in 60 seconds on the leaves of corn and on the glass sides of the cage.

C. L. Scott, on October 7, 1914, at Brownsville, made the following observations on the habits of these flies in the field:

> While collecting Laphygma larvae in a field of young corn I observed flies, *Archytas piliventris*, hovering over corn plants which were infested with large caterpillars. They acted much like bees hovering over flowers. They went from one plant to another, dropping down into infested plants and crawling around over the area where the larvae were at work, apparently ovipositing.

One of the flies captured at that time by Mr. Scott was used the next day in cage experiments in the laboratory, where it was observed to deposit live larvae.

THE LARVAL STAGE

The newly deposited maggots are bluish green in color and lie close to the leaf until disturbed. When disturbed they stand erect and wave their heads about, as may be observed after jarring the leaf by

touching it near the maggots with some object such as a pencil. The maggots usually succeed in crawling upon caterpillars which pass over them. It was difficult to find the maggots after they attached themselves to the caterpillars, and their method of entering the host was not observed.

The length of time that the young maggots can live on the host plant is unknown, but probably many maggots succeed in attacking a caterpillar within a few hours after they are deposited upon the plant.

The length of the larval stage from the time that the maggot enters the caterpillar until the formation of the puparium was not ascertained exactly for each individual under observation, but development is rather rapid. In the experiments summarized in Table 30 it occupied approximately 12 days.

TABLE 30.—*Interval of time from larviposition*[1] *to the emergence of the adult of Archytas piliventris, observed at Brownsville, Tex., in October and November, 1914*

Date of larviposition	Date of emergence of adult Archytas	Number of adults	Interval	Mean temperature	Date of larviposition	Date of emergence of adult Archytas	Number of adults	Interval	Mean temperature
			Days	° *F.*				*Days*	° *F.*
Oct. 7	Oct. 27	1	20	75	Oct. 8	Nov. 4	2	27	74
Do	Nov. 9	1	33	74	Oct. 9	Nov. 5	1	27	74

[1] The caterpillars were removed from the cage and isolated within 6 hours from the time maggots were deposited on the corn leaves by the Archytas females.

The number of days that elapse between the time when the maggot attacks the caterpillar and the pupation of the caterpillar depends upon the stage at which the caterpillar becomes infested. This usually occurs in the fifth or sixth instar, but a few larvae are attacked in earlier stages—probably the fourth instar. In the writer's experiments, in which caterpillars in the fifth and sixth instars were used, pupation of the caterpillar occurred in from 5 to 10 days after it was infested by the maggot. The infested caterpillars are not retarded in development, and pupation occurs at the normal time.

The number of days that elapse between the pupation of the caterpillar and the formation of the puparium also depends upon the stage at which the caterpillar becomes infested. Infestation in the sixth instar, for instance, requires a longer time after pupation. In one instance in October the number of days was 8, but in many of the experiments in rearing it was shorter, and, approximately, the variation was between 4 and 10 days.

THE PUPARIAL STAGE

Usually the exact length of the puparial stage was not observed in the experiments at Brownsville. The puparium is formed within the host pupa several days after pupation. Within two or three days after the puparium is formed the host pupa turns black, and the presence of the parasite may be ascertained readily, as the anal portion of the pupa, which projects beyond the puparium, can be broken off and the puparium removed.

The length of time that elapses between the pupation of the caterpillar and the emergence of the adult fly is subject to considerable

variation, because the length of the puparial stage depends upon the temperature. In June (Table 31), at a mean temperature of 80° F., it ranged from 14 to 19 days, with an average of about 16 days. In December and January, with a mean temperature of 57°, it was about 52 days, about 43 days being spent in the puparium.

TABLE 31.—*Interval of time from the pupation of the caterpillar of Laphygma to the emergence of the adult Archytas piliventris at Brownsville, Tex., in 1910, 1912, 1913, and 1914*

Date of pupation of caterpillar	Date of emergence of adult Archytas	Number of caterpillars	Interval	Mean temperature
1910	1910		*Days*	° *F.*
Oct. 5	Oct. 24	1	19	
1912	1913			
Dec. 5	Jan. 27	1	53	57
Dec. 6	Jan. 26	1	51	57
1913				
Jan. 17–20	Mar. 4–10	1	43–52	63
Apr. 24	May 15	1	21	75
May 3 [1]	May 21	3	18	78
May 4	May 22	1	18	78
May 9	May 26	1	17	78
June 1	June 16	1	15	80
Do	June 17	2	16	80
Do	June 18	1	17	80
Do	June 19	1	18	80
Do	June 20	1	19	80
June 3	June 17	1	14	79
Do	June 19	1	16	80
June 4	do	1	15	80
Do	June 21	2	17	80
June 6	June 20	1	14	80
1914	1914			
Oct. 12	Oct. 27	1	15	74
Oct. 16	Nov. 9	1	24	70
Oct. 14–18	Nov. 4	2	17–21	71
Oct. 19	Nov. 5	1	17	71

[1] The observations in May and June, 1913, were made by E. G. Smyth.

One puparium was formed on October 13, 1910, and the adult emerged on October 24; the puparial stage therefore occupied 11 days, which appears to be about the average for June and October, at a mean temperature ranging from 70° to 80° F. But in one of the experiments conducted in October, 1914, this stage required only about 8 days. It may therefore be considered that the duration of the puparial stage ranges from about 8 days in the summer to about 43 days in December and January.

SUMMARY OF DEVELOPMENTAL PERIOD

Archytas piliventris is diurnal in habit. The females deposit maggots on the host plant of the caterpillar, and some of the maggots attach themselves to the caterpillar when it passes over them. These maggots penetrate through the skin of the caterpillar, and their entire subsequent life until the emergence of the adult fly is spent within the host, which enters the soil and pupates in the normal manner. The maggot eats out nearly all the contents of the

pupated host and forms its puparium within the empty skin in from 4 to 10 days after pupation of the caterpillar. The adult fly emerges in from 8 to 43 days after the formation of the puparium.

The total length of the life cycle of *A. piliventris*, from the time the maggots attached themselves to the caterpillars to the emergence of the adults, is summarized in Table 30 for several experiments conducted in the month of October. A larger number of flies than are listed in Table 30 were bred in these experiments but the time of the emergence of each was not recorded, and only the first and last individuals are tabulated in the experiment of October 7. As is shown, the length of the cycle varied from 20 to 33 days, at an average temperature of 74° F.

SEASONAL HISTORY, OTHER HOSTS, AND NATURAL ENEMIES

Archytas piliventris was reared from caterpillars of *Laphygma frugiperda* collected in every month in the year except February and July (Tables 7 and 8) and was reared from other hosts collected in February. It therefore appears to be active throughout the year at Brownsville but is most numerous in April, infesting (Table 8) 19 per cent of all of the large caterpillars collected in that month.

As the female of this fly does not deposit her larvae on the host plant until 8 or 10 days after she emerges from the puparium, a complete generation in the summer months requires about 30 days. In the winter months the period appears to be about 60 days. Probably from 8 to 10 generations occur during the year at Brownsville.

At Brownsville *Archytas piliventris* was reared from *Cirphis latiuscula* (H. S.) and from *Cirphis unipuncta* (Haw.).

No enemies of *Archytas piliventris* were observed and no parasites were reared, but as no puparia were collected from the field for the purpose of rearing parasites the writer can not say that there are no parasites of Archytas at Brownsville.

(Sporotrichum) XVI. 275

BEAUVERIA GLOBULIFERA (SPEG.)

Beauveria globulifera is a common fungous parasite on lepidopterous larvae in southern Texas. As a destroyer of caterpillars of *Laphygma frugiperda* it is outranked (Tables 7 and 8) only by the hymenopterous parasites *Chelonus texanus*, *Meteorus laphygmae*, and *Sagaritis dubitatus*, and by the tachinid parasite *Archytas piliventris*.

Caterpillars of *Laphygma frugiperda* infested with *Beauveria globulifera* were collected in every month in the year except February, June, August, and September (Tables 7 and 8); and caterpillars of *Cirphis latiuscula* infested with this fungus were collected in February. As only two infested caterpillars were collected in July, the practical absence of this fungus from collections made in June, July, August, and September is noticeable. These are not only the hottest months of the year at Brownsville but, usually, heavy rains occur in May, June, August, and September.

Caterpillars of Laphygma killed by this fungus were observed to be rather numerous in cornfields in November, 1913. On November 4 the writer observed 4 caterpillars which were covered by the white

mycelium of this fungus, and 18 of these dead caterpillars were counted in about one hour in a cornfield on November 26. Caterpillars of Laphygma infested with *Beauveria globulifera* were also numerous in collections made in October, November, and December, 1913, infesting 9.5 per cent of larvae collected in November and December and 2.3 per cent of larvae collected in October, whereas very few infested caterpillars were collected in these months in the years 1914 and 1915.

Larvae attacked by *Beauveria globulifera* usually die stretched out at full length, in the fourth, fifth, or sixth instar. When dead they are rigid, and some of them look lifelike; but they soon become covered by a white mycelium, upon which green spores appear later.

At Brownsville, in the months named, caterpillars of the following species were collected, which were infested with this fungus: *Feltia annexa* Treit, in April and May; a species of Prodenia, in April; a species of Autographa, in April and March; *Euremus eurytheme* Bdv., in March; *Heliothis obsoleta* (Fab.) and *Lycophotia margaritosa* Haw., in February; *Cirphis latiuscula* (H. S.), in November, February, March, and April; and *Cirphis unipuncta* (Haw.), in March.

SPILOCHALCIS PALLENS (CRESSON)[23]

Spilochalcis pallens is parasitic on some of the parasites of Laphygma or hyperparasitic on *Laphygmae frugiperda*. It was reared in July, 1912, at Brownsville from cocoons of *Meteorus laphygmae* (Table 18) and of *Rogas laphygmae* (p. 35), the cocoons having been collected from Bermuda grass at the time of a local outbreak of the fall army worm. At this time 30 per cent of the Meteorus cocoons were infested with this parasite. In June and in September, 1914, it was reared from cocoons of *M. laphygmae* collected from corn (p. 33). In the course of some laboratory experiments it was bred from cocoons of *Apanteles marginiventris* Cresson, but it was never reared from Apanteles cocoons collected in the field.

According to the data collected at the Brownsville field station, *Spilochalcis pallens* appears to be the most important of the parasites of *M. laphygmae* in southern Texas; and under certain conditions it may seriously reduce the effectiveness of this parasite as a destroyer of noctuid caterpillars.

Two female *S. pallens* which were reared from cocoons collected September 16, 1914, were kept in a large vial and fed regularly on sugar sirup. They lived until November 26, or about 71 days, having been kept in a room where the temperature was above 70°.

Females of this species were observed ovipositing; one completed oviposition in a cocoon of *A. marginiventris* in about 10 minutes. The Meteorus cocoons are much harder, and one female consumed 45 minutes in ovipositing in one of them.

THE LARVAL STAGE

A large number of experiments on the developmental period of *Spilochalcis pallens* (Table 32) were performed in October and November, 1914, *Meteorus laphygmae* serving as a host. The cocoons of

[23] Hymenoptera, Chalcididae.

M. laphygmae are nearly transparent, and it is possible to determine when pupation of the host or of the parasite has occurred by examining the cocoon under a binocular microscope by transmitted light.

The duration of the larval stage in October ranged from 5 to 9 days. In the early part of October, at a mean temperature of 80° F. and a range in temperature of 75° to 84°, the average duration was approximately 6 days; at a mean temperature of 75°, with a range of from 62° to 84°, the average time was 8 days.

TABLE 32.—*Record of experiments on the developmental period of Spilochalcis pallens. Meteorus laphygmae being used as a host, at Brownsville, Tex., in October and November, 1914*[1]

Date of oviposition	Date of pupation	Larval stage		Date adults emerged	Number of adults[2]	Pupal stage		Developmental period	
		Length	Mean temperature			Length	Mean temperature	Total length	Mean temperature
		Days	*° F.*			*Days*	*° F.*	*Days*	*° F.*
Oct. 5	Oct. 12	7	80	Oct. 19	1	7	73	14	76
Do	do	7	80	Oct. 21	1	9	73	16	77
Oct. 7	do	5	80	do	5	9	74	14	76
Oct. 8				Oct. 20	2			12	76
Oct 9	Oct. 16	7	76	Oct. 24	2	8	76	15	76
Oct. 10	Oct. 18	8	75	do	1	6	78	14	76
Do	do	8	75	Oct. 25	2	7	77	15	76
Do	Oct. 19	9	76	do	2	6	76	15	76
Do	do	9	76	Oct. 27	2	8	75	17	75
Oct. 12	do	7	74	do	1	8	75	15	74
Do	Oct. 20	8	75	do	1	7	74	15	74
Do	do	8	75	Oct. 28	2	8	73	16	74
Do	Oct. 21	9	75	Oct. 29	1	8	72	17	73
Do	do	9	75	Oct. 30	2	9	72	18	73
Do	Oct. 20	8	75	Oct. 29	1	9	73	17	74
Nov. 3				Nov. 28	3			25	68

[1] The dates given in the first column, except Oct. 5, are the dates the parasites were removed from the cage; they were placed in the cage the day previous; the dates given in the other columns are those upon which the observations were made; the numbers given under the columns for length of larval stage, pupal stage, and total length of life are figured from the dates given, and the actual number of days may in each case have been 1 more or 1 less. The length of the larval stage from Oct. 5 to Oct. 12 may have been 1 day less, or approximately 6 days.

[2] All males.

THE PUPAL STAGE

The length of the pupal stage (Table 32) ranged from 6 to 9 days. At mean temperatures ranging from 76° to 78° F. the average duration was 7 days; at mean temperatures ranging from 72° to 75° it was 8 days.

INTERVAL FROM OVIPOSITION TO THE EMERGENCE OF THE ADULT

With *Meteorus laphygmae* as a host, the interval from oviposition to the emergence of the adult was 14 days, at a mean temperature of 76° F., and 16 days at a mean temperature of 74°. During the progress of these experiments the lowest daily minimum temperature was 62° and the highest daily maximum 84°. There was a sudden drop in temperature on October 13, which retarded the development of the parasites after that time. In November the total interval from oviposition to the emergence of the adult required 25 days, at a mean temperature of 68°.

Two experiments (Table 33) were performed, *Apanteles margini-ventris* being used as a host. In one experiment, begun on October 7, the total interval from oviposition to emergence was from 12 to 14 days, at a mean temperature of 76° F., whereas in November it was about 28 days, at a mean temperature of 66°.

TABLE 33.—*Record of experiments on the developmental period of Spilochalcis pallens, at Brownsville, Tex., in October and November, 1914, Apanteles marginiventris being used as a host*

Date of oviposition	Date adults emerged	Number of adults [1]	Total length of developmental period	Mean temperature
			Days	° *F.*
Oct. 7	Oct. 19	2	12	76
Do.	Oct. 20	2	13	76
Do.	Oct. 21	1	14	76
Nov. 10	Dec. 8	2	28	66

[1] All males.

PARTHENOGENESIS

The adults of this species were kept in vials 28 mm. by 100 mm. in size, and, although the males courted the females much of the time, they were not observed in the act of copulation. As all of the progeny bred in the experiment on life history were males, it is probable that this species can reproduce parthenogenetically.

SPILOCHALCIS TORVINA (CRESSON) [24]

Spilochalcis torvina was reared from cocoons of *Meteorus laphygmae* collected from corn in September, 1914 (p. 33), but was not reared from collections of *M. laphygmae* from corn made in June of that year. Less than one-half of 1 per cent of all of the Meteorus cocoons collected in cornfields in June and September of that year were infested with this species. Of Mr. Smyth's collections (Table 18) of cocoons of *M. laphygmae* taken from Bermuda grass in July, 1912, 16 per cent were infested with *S. torvina*, which was next in importance to *S. pallens* as a parasite of *M. laphygmae*.

This parasite was not reared at Brownsville from cocoons of *Apanteles marginiventris*, *Sagaritis dubitatus*, or *Rogas laphygmae*.

Two female *S. torvina* reared from Meteorus cocoons collected September 16, 1914, were kept in large vials and fed regularly on sugar sirup. One of them lived until April 10, 1915, and the other died a few days earlier. These parasites lived about six and one-half months. They were kept in the office, where the temperature was above 70° F. the greater part of the time.

Several experiments (Table 34) were carried on in October and November, 1914, to obtain information concerning the developmental period of *S. torvina*. *M. laphygmae* was used as the host insect.

[24] Hymenoptera, Chalcididae.

TABLE 34.—*Experiments on the developmental period of Spilochalcis torvina, at Brownsville, Tex., in October and November, 1914, Meteorus laphygmae being used as a host*

Date of oviposition [1]	Date of pupation	Larval stage		Date adults emerged	Number of adults [2]	Pupal stage		Developmental period	
		Length	Mean temperature			Length	Mean temperature	Total length	Mean temperature
		Days	° *F.*			*Days*	° *F.*	*Days*	° *F.*
Oct. 12	Oct. 20	8	75	Oct. 29	2	9	72	17	74
Oct. 19				Nov. 6	1			18	73
Do				Nov. 7	1			19	73
Nov. 10	Nov. 17	[3] 7–9	68	Dec. 7	2	20	65	28	66

[1] See footnote under Table 32.
[2] All males.
[3] The date on which the parasites were placed with the cocoons was not recorded.

In October the length of the larval stage was about 8 days, at a mean temperature of 75° F. In the same month the length of the pupal stage was 9 days, at a mean temperature of 72°, and in November it was 20 days, at a mean temperature of 65°.

The length of the total period from oviposition to the emergence of the adult ranged from 17 to 19 days in October, at a mean temperature of 73° F.; in November it was approximately 28 days at a mean temperature of 66°.

Males and females of *S. torvina* were kept in large shell vials 28 by 100 millimeters in size, and fed on sugar sirup, but were never observed in the act of copulation. Although it is not certain that the females used in the life-history experiments recorded in Table 34 were unfertilized, the fact that all of the progeny were males indicates that they were not and that this species can reproduce parthenogenetically.

DIBRACHYS METEORI GAHAN [25]

Dibrachys meteori was reared at Brownsville from cocoons of *Meteorus laphygmae*, *Sagaritis dubitatus*, and *Rogas laphygmae*, collected in the field. It was not reared from collected cocoons of *Apanteles marginiventris;* but in laboratory experiments it was bred from cocoons of all the four species of parasites here named.

Of 206 cocoons of *M. laphygmae* collected from corn in June, 1914 (p. 33), 3 per cent were infested with *D. meteori;* but a larger number of cocoons collected in September were uninfested. In July, 1912, 12½ per cent (Table 18) of cocoons collected, chiefly from Bermuda grass, were so infested.

Of 14 cocoons of *A. marginiventris* collected in June, 1914, none were infested with Dibrachys, but, owing to the small number of cocoons collected, this fact is not especially significant.

Of 332 cocoons of *S. dubitatus* collected from corn (p. 38) in June, 1914, 2.7 per cent were infested with Dibrachys.

Of 124 cocoons of *R. laphygmae* collected from corn in June, 1914 (p. 35), 4.8 per cent were infested with this species; but it was not reared from the few cocoons collected from Bermuda grass in July, 1914.

[25] Hymenoptera, Pteromalidae.

The writer observed this species ovipositing in a cocoon of *M. laphygmae* on June 17, 1914. The parasite first walked all over the cocoon, exploring it carefully with the tips of her antennae. When a suitable place was found she bent her abdomen down and placed the tip of her ovipositor in contact with the cocoon, directly under the middle of her body. Then she brought her abdomen back to its normal position, and the ovipositor, freed from its sheath, was left pointing directly downward from the cephalic part of the abdomen. Then, with short, quick jabs, she slowly drilled a hole through the wall of the cocoon, this task occupying about one hour. After ovipositing, she worked at the hole in the cocoon with her mouth until she closed it. The cocoons in which she oviposited were spun two days previously, and the Meteorus were in the pupal stage. The location selected for oviposition was near the cap end of the cocoon, and was so located that the egg could be placed in the thorax of Meteorus from the dorsal side.

When disturbed and compelled to give up the work of drilling in one cocoon, this female returned later and continued drilling in the same hole.

It is possible to watch with a binocular microscope, by transmitted light, the development of Dibrachys in cocoons of Meteorus. An unmated female of *D. meteori*, reared from Meteorus, oviposited in six Meteorus cocoons on June 17, 1914. The cocoons were spun on June 16; on June 20 they were examined, and the white pupae of Meteorus could be seen, but four of the pupae were shortened and did not appear normal. On the 21st two of the cocoons contained mature yellow pupae or adults of Meteorus; in the other four cocoons the pupae had shriveled, and Dibrachys larvae had emerged from them. On the 22d the Meteorus adults emerged, and the Dibrachys pupated. On the 23d the Dibrachys pupae were yellow, and later, as they matured, they gradually changed to black. Three male Dibrachys emerged on the morning of the 27th, and another within the following 24 hours. The larval stage was about four days in length, and the pupal stage about six. The average temperature of the laboratory was 83° F.

Experiments were conducted on the developmental period of *D. meteori*, the results of which are contained in Table 35. Cocoons of *Sagaritis dubitatus*, *Rogas laphygmae*, *Apanteles marginiventris*, and *Meteorus laphygmae* were used as hosts.

TABLE 35.—*Experiments on the developmental period of Dibrachys meteori at Brownsville, Tex., in June, 1914*

Host	Date of oviposition	Date adults emerged	Adults		Total length of developmental period	Mean temperature
			Number	Sex		
					Days	° *F.*
Sagaritis dubitatus	June 8	June 18	3	Male	10	82
Rogas laphygmae	June 19	June 30	1	Female	11	83
Apanteles marginiventris	June 18	June 27	3	Male	9	83
Do	do	June 28	1	Female	10	83
Meteorus laphygmae	June 17	June 27	4	Male	10	83

EUPELMINUS METEORI GAHAN [26]

Eupelminus meteori was reared in July, 1912, by E. G. Smyth (Table 18) from cocoons of *Meteorus laphygmae*. Of 231 cocoons collected by him at that time, 3.5 per cent were parasitized by this species. It was not reared from other collections of Meteorus cocoons, nor from collections of cocoons of *Apanteles marginiventris*, *Rogas laphygmae*, or *Sagaritis dubitatus*.

TETRASTICHUS EUPLECTRI GAHAN [27]

Tetrastichus euplectri was reared from cocoons of *Euplectrus platyhypenae* collected (p. 45) at Tallulah, La.

TETRASTICHUS DOLOSUS GAHAN [27]

Tetrastichus dolosus also was reared from cocoons of *Euplectrus platyhypenae* collected (p. 45) at Tallulah, La.

MYRMICOMORPHA PERNICIOSA VIERECK [28]

Myrmicomorpha perniciosa was reared from collections of cocoons from Bermuda grass at the time of a small local outbreak of *Laphygma frugiperda* as an army worm, in July, 1912, at Brownsville.

From 6 cocoons of *Rogas laphygmae* collected by E. G. Smyth (p. 35) in July, 1912, 1 *M. perniciosa* was reared. None were reared from 124 cocoons collected from corn in June, 1914.

Of 231 cocoons of *Meteorus laphygmae* collected by Mr. Smyth in 1912 at Brownsville (Table 18), 4.8 per cent were infested by Myrmicomorpha; but the latter was not reared from 774 cocoons of Meteorus collected from corn in June and September, 1914.

This parasite was not reared from cocoons of *Apanteles marginiventris*, nor from cocoons of *Sagaritis dubitatus*.

HEMITELES [29]

A species of Hemiteles was reared from cocoons of *Meteorus laphyygmae*, *Rogas laphygmae*, *Sagaritis dubitatus*, and *Apanteles marginiventris*, collected at Brownsville. In laboratory experiments it was bred from *Sagaritis dubitatus* and *Apanteles marginiventris*.

From 206 cocoons of *M. laphygmae* collected from corn in June, 1914, 11 Hemiteles (p. 33) were reared, but none were reared from 568 cocoons collected in September. Of 231 cocoons (Table 18) of Meteorus collected by E. G. Smyth from Bermuda grass and other plants in July, 1912, 9.5 per cent were infested with Hemiteles.

From 332 cocoons (p. 38) of *S. dubitatus* collected from corn in June, 1914, 2 Hemiteles were reared.

Of 14 cocoons of *A. marginiventris* collected from corn in June, 1914 (p. 28), 2 were infested with Hemiteles.

Of 6 cocoons of *R. laphygmae* collected from Bermuda grass (p. 35) by Mr. Smyth in July, 1912, 1 was infested with Hemiteles. Of 124 cocoons collected from corn (p. 35) in May and June, 1914, 5 were infested with Hemiteles.

In June, 1914, the writer observed a Hemiteles ovipositing in a cocoon of *S. dubitatus*. The parasite examined the cocoon, first

[26] Hymenoptera, Eupelmidae.
[27] Hymenoptera, Eulophidae.
[28] Hymenoptera, Ichneumonidae, Cryptinae, Gelini.
[29] Hymenoptera, Ichneumonidae, Cryptinae, Hemitelini.

facing toward one end of it and then toward the other. Then bending her abdomen under her, she placed the point of her ovipositor in contact with the cocoon; as she slipped the ovipositor out of its sheath and brought her abdomen back to its normal position the ovipositor was left under the middle of her abdomen and pointed forward. She next pressed the ovipositor in a slanting direction into the cocoon until the latter was touched by the tip of the abdomen. Resting on the tip of the abdomen and using it as a fulcrum, she partly withdrew the ovipositor and pressed it in again until the desired spot was reached. She had no difficulty in penetrating the cocoons.

In another instance one female was observed to oviposit in three cocoons of *S. dubitatus* in 30 minutes.

Three experiments on the developmental period of Hemiteles were conducted in June, 1914, *S. dubitatus* and *A. marginiventris* being used as hosts. Two males were bred from Sagaritis, the dates of oviposition being June 19 and June 23, and in each case the length of time from oviposition to the emergence of the adult was 10 days, at an average daily mean temperature of 83° F. One male was bred from Apanteles and again the interval from oviposition (on June 19) to the emergence of the adult was 10 days, at a mean temperature of 83° F.

In the case of the two experiments in which *S. dubitatus* was used as the host, the two female Hemiteles were reared from *M. laphygmae* and had not been confined with males. Nine cocoons of Sagaritis were used in the oviposition of June 23 and three in that of June 19. On the latter date the female was observed to oviposit in all three cocoons. In these experiments only two adults were reared from the 12 cocoons. Of the cocoons used some were 1 day old and some 2 days old.

In the experiments in which *A. marginiventris* was used as host 21 cocoons, spun on the day the parasites were placed with them, were used, and male and female Hemiteles reared from *R. laphygmae* were confined with them.

The times of oviposition and of emergence of the adults were rather accurately observed, and the developmental period was somewhat less than 10 days, or about 9½ days.

COMPARISON OF THE BIONOMICS OF THE PARASITES

Some interesting information has been brought out in the preceding pages concerning the habits of the various species of parasites, their alternate hosts, and secondary parasites. It is believed that a few comparisons of the parasites in these respects, briefly summing up some of the points already brought out, will be of advantage.

ALTERNATE HOSTS

The writer and his associates collected and reared caterpillars of many species for the purpose of determining the alternate hosts of the Laphygma parasites. Many species were reared from *Laphygma exigua* and from various species of Prodenia, as well as from *L. frugiperda*. Prodenia caterpillars of five species[30] were collected

[30] *Prodenia latifascia* Walker, *P. praefica* Grote, *P. ornithogalli* Guenee, *P. eridania* (Cramer), and *P. eudiopta* Guenee were collected at Brownsville, but the species of caterpillars were not sorted before parasites were reared from them.

frequently from corn, alfalfa, tomato, and Amaranthus. *L. exigua* was collected from alfalfa and corn. *Heliothis obsoleta*, present in the same cornfields, had a different group of parasites. Some of the Laphygma parasites, *Chelonus texanus*, *Meteorus laphygmae*, *Sagaritis dubitatus*, and *Apanteles marginiventris*, attack Heliothis; but each species has parasites which were not reared from the other. The various army worms, Cirphis, also have parasites, *A. militaris* Walsh, *A. rufocoxalis* Riley, and others, which do not attack the species of Laphygma, even though both species of caterpillars are present in the same fields. All of the parasites of Laphygma appear to have other hosts, and none of them, with the possible exception of *Rogas laphygmae*, seems to be limited exclusively to Laphygma as a host.

SECONDARY PARASITES

It will be noted that secondary parasites were reared from the cocoons of 5 species of primary parasites, *Meteorus laphygmae*, *Apanteles marginiventris*, *Rogas laphygmae*, *Sagaritis dubitatus*, and *Euplectrus platyhypenae*, 10 species of secondary parasites being reared. Generally the secondary parasites infested only a small percentage of the individuals of the primary parasites, and secondary parasitism in the vicinity of Brownsville seemed not to reduce the effectiveness of the primary parasites to any appreciable extent; this was especially true in the cornfield.

Secondary parasites were not reared from the cocoons of *Chelonus texanus*, *Neopristomerus appalachianus*, or *Ophion bilineatus*, or from the puparia of *Archytas piliventris;* but, as no cocoons of these species were collected from the field, it is not at present known whether or not these species have secondary parasites.

OVIPOSITION

Apanteles marginiventris oviposits in first-instar larvae which have recently emerged. This habit is of great advantage to this species, as it can oviposit in many larvae from one egg mass, attacking them soon after they emerge from the eggs and before they have dispersed, instead of hunting over the plant for individual larvae. The habit possessed by *Chelonus texanus* of ovipositing in the egg is an improvement over that of Apanteles, as it is able to infest a very large number of caterpillars with little difficulty. All of the other ovipositing species have to hunt out and oviposit in the isolated caterpillars, whereas *Archytas piliventris* deposits its larvae on the plant, where many of them perish while waiting for a caterpillar to come their way.

SPINNING COCOONS

Some interesting facts were observed concerning the building of the cocoons. *Ophion bilineatus* and *Chelonus texanus*, for instance, build their cocoons within cells in the ground, and the larva is unable to start its cocoon unless it finds support for it on all sides. Sagaritis has to have support for the cocoon on only one side, as it attaches the cocoon to the leaf of the plant, whereas Meteorus shows a more advanced method of building a cocoon, being able to spin a free cocoon, constructing the framework around itself without attaching the threads to anything except to the short stem of silk which attaches the cocoon to the plant or other object.

PARTHENOGENESIS

Some of the hymenopterous parasites studied were observed to reproduce parthenogenetically. *Meteorus laphygma*, *Apanteles marginiventris*, *Rogas laphygmae*, *Dibrachys meteori*, and Hemiteles reproduce parthenogenetically, and the progeny of unfertilized females are males. *Chelonus texanus* and *Euplectrus platyhypenae* also reproduce parthenogenetically, and the progeny of unfertilized females probably are males, although the sex was not positively determined in the experiments at Brownsville. *Spilochalcis pallens* and *S. torvina* probably reproduce parthenogenetically, and the progeny of unfertilized females probably are males. These species of Spilochalcis were not observed to mate in the experiments, and only males were produced in the experiments on the developmental period.

SEASONAL HISTORY

Most of the parasites of *Laphygma frugiperda* pass through many generations in the course of the year, and, like their host, are active throughout the year at Brownsville. No evidence was found that they are able to pass the winter in an inactive stage.

The duration of the developmental period, from oviposition to the emergence of the adult (Table 36) in *Chelonus texanus*, *Ophion bilineatus*, and *Archytas piliventris* is approximately the same as in *Laphygma frugiperda*. This adaptation to the developmental period of the host may be of advantage to Chelonus and Archytas at Brownsville, where early and late plantings of corn may be found on the same farm. Laphygma moths emerging from early cornfields find corn near by in a suitable stage for oviposition, and the parasites which emerge at about the same time as the moths can find caterpillars in fields adjacent to those from which they emerge. In other localities, however, the lack of suitable host plants may cause a wide dispersion of the moths, and the parasites may be compelled to seek other hosts.

The other species listed in Table 36 complete their life cycle in about one-half the time required by Laphygma. At Brownsville these species can find caterpillars of Laphygma in the early instars in nearly every month of the year, but especially in the cornfields during April and May. Probably, however, they depend largely on other hosts, even at Brownsville, and in more northern localities alternate hosts would be necessary.

TABLE 36.—*Duration of the various stages of Laphygma frugiperda, compared with the duration of the same stages of its principal parasites, at average temperatures between 74° and 79° F. at Brownsville Tex.,*

Species	Egg stage	Larval stage	Pupal stage	Total of all stages observed
	Days	*Days*	*Days*	*Days*
Laphygma frugiperda	2½	17	10	30
Chelonus texanus	----------	[1]16	12	28
Apanteles marginiventris	----------	[1]8	6	14
Meteorus laphygmae	----------	[1]10	6	16
Rogas laphygmae	----------	[1]8	5	13
Sagaritis dubitatus	----------	[1]8	6	14
Ophion bilineatus	----------	[1]10	20	30
Euplectrus platyhypenae	3	4	6	13
Archytas piliventris	----------	12	15	27

[1] Duration of the egg and larval stages combined.

COMPETITION BETWEEN PARASITES

One important problem connected with parasitism is the question of competition between the parasites. More than one species may attack the same individual caterpillar, and if the less efficient species survives, its attack serves to reduce the numbers of the more efficient species.

For instance, *Chelonus texanus* oviposits in the egg of its host, and unless the egg stage of Chelonus is very long it should have the advantage of an early start over the other parasites that subsequently attack the same host; but the duration of the combined egg and larval stages of Chelonus is comparatively great (Table 36), and it is possible that a rapidly growing parasite, even though hatched later, might survive and destroy the Chelonus larva. Again, three species of parasites, *Euplectrus platyhypenae*, *Ophion bilineatus*, and *Archytas piliventris*, attack the later instars of caterpillars, and may sometimes attack caterpillars which are already infested with a rapidly developing species of parasite, well advanced in development. This may cause the death of the host within a few hours or days after these species oviposit, thus preventing their development.

Three of the species which are likely to come into competition with *Chelonus texanus* are *Rogas laphygmae*, *Apanteles marginiventris*, and *Sagaritis dubitatus*. In April or May, at mean temperatures of 79° F., the duration of the combined egg and larval stages (Table 36) of each of these species is 8 days, whereas this period averages 16 days for Chelonus. Apanteles oviposits in first-instar caterpillars, as also may Sagaritis and Rogas. Any one of these species may therefore oviposit in a caterpillar from 1 to 4 days after the oviposition of Chelonus, and their larvae may emerge from the host caterpillar and spin cocoons 4 to 7 days earlier than the larvae of Chelonus from the same egg mass. Caterpillars infested with these three species are retarded in development, and never become as large as those infested with Chelonus. It therefore seems probable that these species are likely to survive at the expense of Chelonus if their eggs are deposited in caterpillars already infested with it.

These three species also develop in a shorter time than does *Meteorus laphygmae*, and oviposit usually in younger caterpillars than Meteorus; it follows that they may likewise develop at the expense of that species.

M. laphygmae often oviposits in first-instar caterpillars, and as it develops in a shorter time than does Chelonus it may sometimes destroy larvae of that species.

Euplectrus platyhypenae develops very rapidly and may destroy caterpillars infested with *Ophion bilineatus* or *Archytas piliventris*.

It seems possible that a large number of species of parasites attacking the same host may result in less, rather than more, effective control of that host. But to reach more definite conclusions concerning the conflict between the parasites of Laphygma it will be necessary to carry on further experiments and to study the life history of the various parasites in detail by dissecting the infested caterpillars.

Chelonus texanus is the most important parasite of Laphygma in southern Texas, and it follows that those species which come into competition with it are of doubtful value. In other localities, however, Apanteles, Meteorus, and Sagaritis may be more important

than Chelonus, or they may occur in large numbers at a time when Chelonus is not present. At Brownsville all of these species were at times reared in large numbers from single collections; Meteorus 40 per cent, Sagaritis 43 per cent, and Apanteles 18 per cent, where 100 or more caterpillars were collected at one time, and even higher percentages were reared in smaller collections.

IMPORTANCE OF PARASITES IN PROTECTING CORN FROM THE ATTACKS OF LAPHYGMA FRUGIPERDA

Parasites are probably not of great importance in reducing the numbers of *Laphygma frugiperda* in the United States, for the reason that the results of parasitism in this respect are outweighed by the results of the dispersion of the moths. The migrations of the moths northward each year carry them into areas where their progeny are destroyed by cold weather early in the winter.

Parasites are, however, of local importance in protecting crops, especially corn. This is undoubtedly true at Brownsville, where corn is commonly severely injured by Laphygma larvae, although the varieties of corn which have been proven to be adapted to that locality usually outgrow the attacks of these caterpillars and other insects. Not all of the species of parasites that attack Laphygma are effective in protecting the plant, as some allow the caterpillars to reach the sixth instar and do almost as much damage as uninfested caterpillars; but other species destroy the caterpillars in the early instars, before they do serious injury to the plant. The species that kill the host during the early instars, *Apanteles marginiventris*, *Rogas laphygmae*, *Sagaritis dubitatus*, *Meteorus laphygmae*, and *Chelonus texanus*, destroy together in April, May, and June from 40 to 50 per cent of the Laphygma caterpillars on corn at Brownsville. It seems probable that this percentage is sufficient to save the plants, which are frequently very severely injured by the caterpillars that survive the parasites.

CAUSE OF OUTBREAKS OF THE FALL ARMY WORM

For more than 100 years *Laphygma frugiperda* has been known as a major pest of cereal and forage crops throughout the greater part of the country east of the Rocky Mountains, because of its sudden and unexpected appearance in very large numbers in some years. The outbreaks of the larva, known as the grass worm or fall army worm, occur at yearly intervals usually only in a few States, but at less frequent intervals the attack is general over the eastern part of the country. The history of these outbreaks up to the year 1900, with special consideration of that of 1899, has been given by Chittenden,[31] and the conditions in Alabama during the outbreaks of 1912 and 1915 have been described by Hinds and Dew.[32]

There are, in the writer's opinion, two habits of the moth of *Laphygma frugiperda* that have an important connection with the phenomena of outbreaks of the fall army worm. These are the egg-laying habit and the migratory habit. The migratory habit results in flights of large numbers of moths seeking young plants on which

[31] CHITTENDEN, F. H. Op. cit.
[32] HINDS, W. E., and DEW, J. A. THE GRASS WORM OR FALL ARMY WORM. Ala. Agr. Expt. Sta. Bul. 186, 92 p., illus. 1915.

to oviposit, preferably plants of the family Gramineae, but also of the family Leguminosae. When such plants are available the moths are attracted to them in large numbers. The conditions necessary, then, for an outbreak of the fall army worm are flights of large numbers of moths, combined with a large supply of young food plants.

The cause of the migrations may be understood if it be remembered that this tropical species passes through many generations in the course of a year and that the succulent leaves of young plants are the most favorable food for the larvae. As only one generation can be completed on a young plant, the moths of each generation seek a new supply of young plants. It may be said that the migrations are caused by the instinct of the female to seek for oviposition suitable young food plants for her progeny. The migratory habit is of advantage to the species because it is thereby enabled to escape the cumulative attack of its parasites that would result if the insect remained in the same field through several generations. It is also advantageous in that it helps the insect to escape the result of scarcity of food plants caused by drought or by the feeding of caterpillars of this or any other species.

The general outbreaks occur in the United States as the result of the northward flight of moths. And the question may arise, why do the moths fly northward, since this habit is a disadvantage to the species, in that large numbers of them migrate during the summer into territory where the species is unable to survive the winter? To explain this northward flight it is necessary to assume only that the moths disperse in all directions. This would result in the continuous presence of caterpillars within the Gulf coast region wherever food is available and the presence of caterpillars in small or large numbers in the States farther north as food becomes available with the advance of the season. This northward flight seems to occur every year, the larvae being found commonly as far north as Kansas and Tennessee on corn, sorghum, alfalfa, grasses, and other plants and in smaller numbers in the more northern States.

Such widespread outbreaks of the fall army worm as occurred in 1899 and 1912 seem to be the result of a late season in the South, necessitating the late planting of corn and forage crops over large areas. In most seasons, when the moths in large numbers reach as far north as northern Texas, Louisiana, or Mississippi, the corn crop is well advanced and beyond the stage preferred by them for oviposition. Owing to this fact, oviposition is distributed in fields of corn and other crops scattered over a wider territory. But in occasional years there are spring floods and heavy rains, especially in the lower Mississippi Valley, causing overflows in the river-bottom lands and preventing the early planting of corn. As a result of the replanting or late planting of corn, large numbers of moths are flying by the time the corn is a foot or two high, and they concentrate and oviposit where it is growing. The combined attack of the large numbers of caterpillars that result is so great that the plants are not able to outgrow its effects, and widespread, serious damage to the crop occurs, many acres of corn being totally destroyed. From the caterpillars and the resulting pupae come large numbers of moths of the next generation, which must leave the infested fields; of these some spread to other fields in the South, and others migrate northward, to oviposit on any favorable host plants that they may find. In other words,

the corn and forage crops usually mature ahead of the flight of moths; but in occasional years crops are late, and where they are late the moths concentrate, with the result that there is an outbreak of the fall army worm.

SUMMARY

The moths of *Laphygma frugiperda* disperse from the fields where they emerge from the pupae, apparently in search of suitable plants for oviposition. But the dispersal helps this insect to escape the cumulative effects of parasitism, to which a species passing through many generations a year might be subject. The dispersal also enables it to escape starvation from scarcity of food caused either by the maturing of its host plants or by the destruction of host plants by caterpillars of this or other species. The dispersal, however, is a disadvantage to the species, especially in the United States, because large numbers of the moths reach localities where their progeny are unable to survive the winter and so are destroyed.

The female moths lay an average of 1,000 eggs each, in masses of two to four layers, covered with down from their bodies. There may be as many as 400 eggs in a mass. The eggs are laid on or near food plants suitable for the larvae.

The larvae are gregarious at first, but disperse during the latter part of the first instar. Dispersal of caterpillars in the later stages is forced by their cannibalistic habits. They feed on the leaves of young plants, especially on those of the family Gramineae, but also on those of the family Leguminosae, and less frequently on plants of other families. They prefer coarse grasses, such as corn and the sorghums.

This species passes through many generations in the course of the year, from 9 to 11 generations occurring annually at Brownsville, Tex. Because of its tropical origin it is unable to pass the winter in an inactive (hibernating) stage. At Brownsville all stages are present during the winter, and the limiting factor in that locality appears then to be the scarcity of food, as, on account of the mild winter climate, vegetation there is frequently destroyed by sudden frosts at temperatures which would not be so destructive in more northern localities.

Parasites of this species are rather numerous at Brownsville. The parasites with one exception were found to have other hosts and not to be limited exclusively to *Laphygma frugiperda*. Nearly all of them pass through many generations annually. Parasites relatively are not of great importance in reducing the numbers of this species in the United States because the effect of parasitism is outweighed in this regard by the migration of the moths to northern localities, which results in the destruction of much larger numbers than are destroyed by parasites.

Parasites are important locally as a protection to the corn crop. At Brownsville corn is very generally seriously injured by larvae of Laphygma, but the sturdy varieties grown in that locality usually survive the attacks of this and other insects. During April, May, and June between 40 and 50 per cent of the caterpillars feeding on corn are destroyed by parasites in the early stages. If these caterpillars were permitted to develop normally the increased injury resulting to the foliage of the plants would be more than the plants could survive.

Corn in the South is very generally injured by the larvae of *Laphygma frugiperda*, which feed on the leaves of the young plants. In Texas this injury to corn is known as "bud-worm" injury. Corn and alfalfa are the principal crops injured by this insect in the United States. Small fields of both crops are frequently destroyed by local outbreaks of the fall army worm, and during the great outbreaks widespread damage may occur to both.

Outbreaks of the fall army worm are due to the migrating habit and the egg-laying habit of the moths. The moths seek young plants for oviposition, and when fields of young corn or other suitable young plants occur in localities where large numbers of moths are flying, the latter may concentrate in these fields for oviposition. In such cases large numbers of caterpillars are produced, which may destroy the crop and so cause migration of the caterpillars in armies to other fields. Such outbreaks may occur locally at any time, and they are likely to occur over large areas when climatic conditions cause extensive late planting or replanting of corn in the South. By the time the migrating moths appear in large numbers, the late-planted corn is in the right stage—from 6 to 24 inches high—to attract them.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE

September 25, 1929

Secretary of Agriculture	ARTHUR M. HYDE.
Assistant Secretary	R. W. DUNLAP.
Director of Scientific Work	A. F. WOODS.
Director of Regulatory Work	WALTER G. CAMPBELL.
Director of Extension Work	C. W. WARBURTON.
Director of Personnel and Business Administration.	W. W. STOCKBERGER.
Director of Information	M. S. EISENHOWER.
Solicitor	R. W. WILLIAMS.
Weather Bureau	CHARLES F. MARVIN, *Chief.*
Bureau of Animal Industry	JOHN R. MOHLER, *Chief.*
Bureau of Dairy Industry	O. E. REED, *Chief.*
Bureau of Plant Industry	WILLIAM A. TAYLOR, *Chief.*
Forest Service	R. Y. STUART, *Chief.*
Bureau of Chemistry and Soils	H. G. KNIGHT, *Chief.*
Bureau of Entomology	C. L. MARLATT, *Chief.*
Bureau of Biological Survey	PAUL G. REDINGTON, *Chief.*
Bureau of Public Roads	THOMAS H. MACDONALD, *Chief.*
Bureau of Agricultural Economics	NILS A. OLSEN, *Chief.*
Bureau of Home Economics	LOUISE STANLEY, *Chief.*
Plant Quarantine and Control Administration.	C. L. MARLATT, *Chief.*
Grain Futures Administration	J. W. T. DUVEL, *Chief.*
Food, Drug, and Insecticide Administration	WALTER G. CAMPBELL, *Director of Regulatory Work, in Charge.*
Office of Experiment Stations	E. W. ALLEN, *Chief.*
Office of Cooperative Extension Work	C. B. SMITH, *Chief.*
Library	CLARIBEL R. BARNETT, *Librarian.*

This bulletin is a contribution from

Bureau of Entomology	C. L. MARLATT, *Chief.*
Division of Cereal and Forage Insects	W. H. LARRIMER, *Senior Entomologist, in Charge.*

U. S. GOVERNMENT PRINTING OFFICE: 1929